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Science Policy Study—Hearings Volume 14

DEMOGRAPHIC TRENDS AND THE SCIENTIFIC AND ENGINEERING WORK FORCE

ORIGINAL

HEARINGS

BEFORE THE

TASK FORCE ON SCIENCE POLICY

OF THE

COMMITTEE ON
SCIENCE AND TECHNOLOGY
HOUSE OF REPRESENTATIVES

NINETY-NINTH CONGRESS

SECOND SESSION

FEBRUARY 19, 20, 27, 1986

[No. 106]

Printed for the use of the
Committee on Science and Technology

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DEMOGRAPHIC TRENDS AND THE SCIENTIFIC AND ENGINEERING WORK FORCE

WEDNESDAY, FEBRUARY 19, 1986

House of Representatives,
Committee on Science and Technology,
Science Policy Task Force,
Washington, DC.

The task force met, pursuant to recess, at 8:37 a.m., in room 2325, Rayburn House Office Building, Hon. Don Fuqua (chairman of the task force) presiding.

Mr. Fuqua. Today's hearing is a continuation of the Science Policy Task Force hearings of last year which were initiated to review the role that the Federal Government should play in the support of training of new generation of scientists and engineers.

As most of us know, this morning is part of a larger science policy study being undertaken by the task force under the umbrella of the Science and Technology Committee.

At this hearing we want to broaden our understanding of the factors affecting the longer term supply of personnel trained in science and engineering. We'll also review the availability of faculty at our universities for training of such personnel.

This is important in order for the United States to maintain a leadership role in critical science and technological fields and to gain increased industrial competitiveness.

The Office of Technology Assessment has recently completed a report on demographic trends in the scientific and engineering work force. That report will serve as a focal point for this hearing.

Today we are very pleased to have that report presented by Dr. Gene Frankel, a former member of our staff of the committee and no stranger, and project director of the science policy group at OTA, and also Dr. John Andelin, who spent many years here on the staff, a very valued member, Assistant Director for Science, Information, and Natural Resources, and Nancy Carson Naismith, OTA program manager for Science, Education, and Transportation.

So, Gene, I guess you are the presenter this morning.

[Biographical sketches of Dr. Eugene Frankel, Dr. John P. Andelin, Jr., and Nancy Carson Naismith follow:]

Dr. Eugene Frankel

Dr. Eugene Frankel is a senior analyst in the Science, Education, and Transportation Program of the Office of Technology Assessment of the U.S. Congress. He directed the study, Demographic Trends and the Scientific and Engineering Work Force. Dr. Frankel served for five years on the professional staff of the Committee on Science and Technology of the U.S. House of Representatives, specializing in conservation and renewable energy research and development. He also worked for three years as program manager and policy analyst in renewable energy for the Department of Energy.

Dr. Frankel holds a Ph.D. in history of science from Princeton and a Master's degree in physics from Rutgers. He taught physics and history of science at Trinity College in Hartford and technology studies for the Five College Consortium (Amherst, Hampshire College, Mount Holyoke, Smith, and the University of Massachusetts) in the Amherst-Northampton region.

DR. JOHN P. ANDELIN, JR.

Dr. John P. Andelin, Jr., is Assistant Director of the Congressional Office of Technology Assessment (OTA) for the Science, Information, and Natural Resources Division. Before his appointment at OTA, Dr. Andelin was the staff director for the Subcommittee on Advanced Energy Technologies and Energy Conservation Research, Development, and Demonstration of the Committee on Science and Technology, U.S. House of Representatives. He also served as a science consultant to that Committee and as scientific advisor and administrative assistant to Congressman Mike McCormack (D-Wash.).

Dr. Andelin holds a Ph.D. in physics from the California Institute of Technology and a Master's degree in physics from Stanford University. He has been on the research staffs at Harvard University, Oak Ridge National Laboratory, and the Ford Scientific Laboratory.

NANCY CARSON NAISMITH

Nancy Carson Naismith is Program Manager for work in Science, Education, and Transportation at the Congressional Office of Technology Assessment (OTA). OTA provides analysis of the positive and negative impacts of technology choices for Congress.

Ms. Naismith has worked in the Executive and Legislative branches of the Federal Government since 1962. Her early work includes managerial responsibility in the areas of water quality, open space and neighborhood development, historic preservation, and recreation planning. Since joining OTA in 1977, Ms. Naismith has worked primarily in energy technology, with special emphasis in energy conservation and renewable technologies. She also served as the first Vice President of the "Solar Bank."

She holds a degree in general studies from the University of Washington in Seattle, and a Master's degree in Public Administration from the John F. Kennedy School of Government at Harvard, where she was a Littauer Fellow.

STATEMENT OF DR. EUGENE FRANKEL, PROJECT DIRECTOR, SCIENCE POLICY GROUP, OFFICE OF TECHNOLOGY ASSESSMENT, ACCOMPANIED BY DR. JOHN P. ANDELIN, JR., ASSISTANT DIRECTOR FOR SCIENCE, INFORMATION, AND NATURAL RESOURCES, OFFICE OF TECHNOLOGY ASSESSMENT; AND NANCY CARSON NAISMITH, OTA PROJECT MANAGER FOR SCIENCE, EDUCATION, AND TRANSPORTATION, OFFICE OF TECHNOLOGY ASSESSMENT

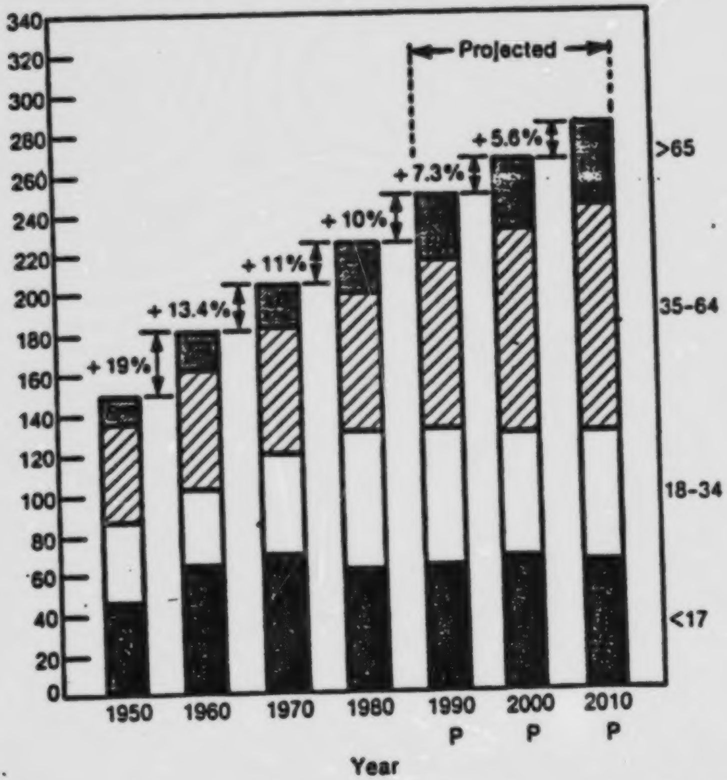
Dr. FRANKEL. That's right. Thank you, Mr. Chairman. It's a pleasure for me to return to the Science Committee and quite a treat to be on this side of the witness table instead of the other side.

The key role of the Federal Government in educating and ensuring an adequate supply of scientists and engineers has been acknowledged since the close of World War II. Scientists and engineers represent only 3.5 percent of the national work force, but are considered to be a crucial element in the Nation's efforts to improve its economic competitiveness and national security. The Office of Technology Assessment was asked by the task force on science policy to examine the implications of long-term demographic trends for scientific and engineering personnel policy, and to consider, as well, the barriers to, and future trends in, the participation of women and minorities in scientific and engineering careers. I'm pleased to be with you today to present some of the findings of that study.

Figure 1, which follows page 1 in your text, shows historical and projected population changes for the United States as a whole from Census Bureau figures between 1950 and the year 2010. As can be seen, the overall rate of population growth decreases from decade to decade, and the fraction of the population in the 35 to 64 and over 65 age brackets increases dramatically.

[The chart follows:]

U.S. Population by Major Age Groups, 1950–2010

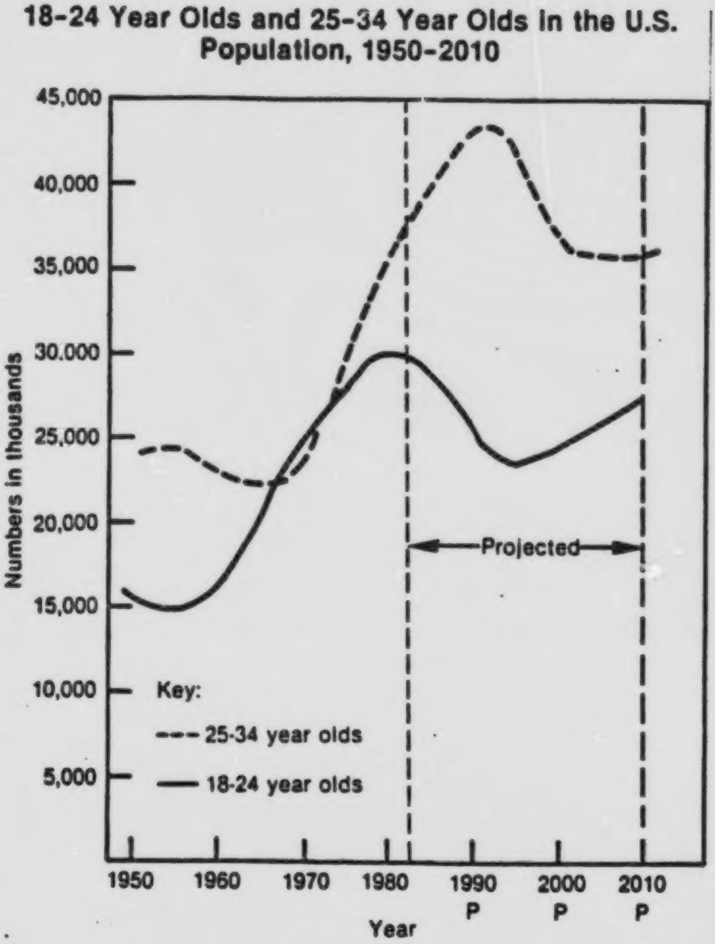


SOURCE: *Projections of the Population of the United States, by Age, Sex and Race: 1983 to 2080*, series P-25, No. 952 (Washington, DC: U.S. Department of Commerce, Bureau of the Census, May 1984), table E, p. 7.

FIGURE 1

Figure 2, and this follows page 2 in your text, shows the projections for two populations of special interest to the study: The 18- to 24-year-olds who form the bulk of the college age population, and the 25- to 34-year-olds who contribute the lion's share of graduate students.

[The chart follows:]



NOTE: Figures for 1983 to 2010 are projected.

SOURCE: *Projections of the Population of the United States, by Age, Sex and Race: 1983 to 2080*, series P-25, No. 952 (Washington, DC: U.S. Department of Commerce, Bureau of the Census, May 1984) table E p. 7.

FIGURE 2

As can be seen, the size of the first group doubled between 1960 and 1980, and is now experiencing a fairly significant decline. This drop should end in 1995 and be followed by a modest recovery. The

25- to 34-year-old age group has been growing since 1970 and will continue to do so through the early 1990's. The peak in about 1995 will be followed by a small decrease though the year 2000 and then a leveling off in the first decade of the 21st century.

Since most students receive their B.A. at age 22 and the Ph.D. at age 30, the first concern raised by these demographic trends is whether these projected declines in population of the two groups could result in shortages of science and engineering baccalaureates and Ph.D.'s. Fortunately, OTA finds this scenario to be unconvincing.

On the undergraduate level, it is entirely possible that the number of people trained in science and engineering will not decline at all, despite the drop in the college age population. The proportion of 25- to 44-year-olds who attend college—on the undergraduate level now—has increased dramatically in the past decade, as has the number of foreign nationals attending U.S. colleges and universities. If increases in college attendance of the 25- to 44-year-olds and foreign nationals continue over the next decade, it could compensate in part for the decline in the number of 18- to 24-year-olds.

Second, there could be increases in the rate at which college students choose to major in science and engineering. Currently, the fraction of 22-year-olds receiving a bachelor's degree in science and engineering fields is near the low point of the last decade. A slight increase in the rate of selection of careers in these fields could more than compensate for the decline in the 18- to 24-year-old population. Projections of shortages might well serve to increase science and engineering enrollments as the labor market responds by promising better pay or better job opportunities.

Third, science and engineering workers can be obtained by employing a higher proportion of those who have the required undergraduate degrees. Less than two-thirds of the science and engineering baccalaureates produced in recent years have actually become part of the science and engineering work force.

Finally, on the graduate level, there appears to be no direct relationship between the number of Ph.D.'s and the size of the graduate school age population. Between 1960 and 1970, for example, the number of science and engineering Ph.D.'s increased nearly threefold. At the same time the population of 25- to 34-year-olds—the group that supplies the majority of graduate students—barely increased at all. Accordingly, the size of the 25- to 34-year-old age cohort does not appear to be closely linked to the supply of science and engineering Ph.D.'s.

It is important to remember that there is no national market for scientists and engineers as a group. Rather, there are specific markets for graduates trained in particular disciplines, and these markets and disciplines can experience very different conditions at the same time. For example, the NSF projected in 1982 that the demand for electrical and aeronautical engineers and computer specialists could exceed the supply of graduates in those fields over the next 5 years. At the same time the NSF projected that there will be surpluses of biologists, chemists, theologists, and physicists. It is thus individual disciplines, especially those linked with high growth or defense-oriented industries, that could experience personnel problems in the future; not science and engineering as a whole.

This finding is encouraging, because individual disciplines have shown great ability to grow and shrink as market conditions require. The number of engineering baccalaureates, for example, more than doubled between 1976 and 1984. The number of computer science B.A.'s tripled between 1977 and 1982. At the same time, B.A.'s in education, foreign languages, anthropology, and other fields all fell significantly. Thus college students appear to be highly responsive to market signals, and to shift their career choices dramatically towards fields that promise greater occupational rewards. OTA concludes—and I think this is an important conclusion for us—that career choices and market forces have a greater impact on the supply of scientists and engineers than does demographics.

OTA finds that the changing college student demographics of the coming decade have several important policy implications for national efforts to promote equality of opportunity in science and engineering. This policy, as you know, was set forth in the Equality of Opportunities in Science and Technology Act of 1981, passed by Congress in part on the initiative of this committee. If the number of science and engineering degrees declines, it will become especially important to utilize all potential human resources to the fullest extent possible. This means that increasing attention should be paid to those groups with historically low participation rates, such as women and some minorities. The increasing fraction of college students that will be drawn from the black and Hispanic populations, which have historically participated in these fields at far lower rates than the white population, imply that programs aimed at these two minority groups could be an especially important source of new talent.

In order to understand what will be required, it is important first to have a clear picture of the factors leading to reduced participation by women and certain minority groups in science and engineering. These factors include: first, the continuing legacy of decades of discrimination and discouragement; second, differential treatment, especially for women, in the science and engineering work force; third, lack of early education opportunities among minorities due to economic, social, and cultural factors; fourth, female socialization patterns that discourage young women from perceived masculine careers; fifth, expectations that women will continue to assume the major role in housekeeping and child rearing; sixth, lack of financial support for minorities in the higher education system; and seventh, lack of role models and early exposure to science and engineering careers.

Now, obviously, many of these factors reflect broader social problems which cannot be remedied by science policy alone, although there is considerable evidence that special science education programs for women and minorities can compensate to some degree for the disadvantages experienced by these groups.

A 1984 report on "Equity and Excellence" by the American Association for the Advancement of Science recommends several attractive options to remedy this problem, and these are discussed in my written statement.

It should be noted that the lower participation in scientific and engineering careers among blacks, Hispanics, and American Indians does not extend to all minority groups. Asian Americans in particular are participating in these fields in record numbers and doing very well at it. It would be useful to understand more about this phenomenon.

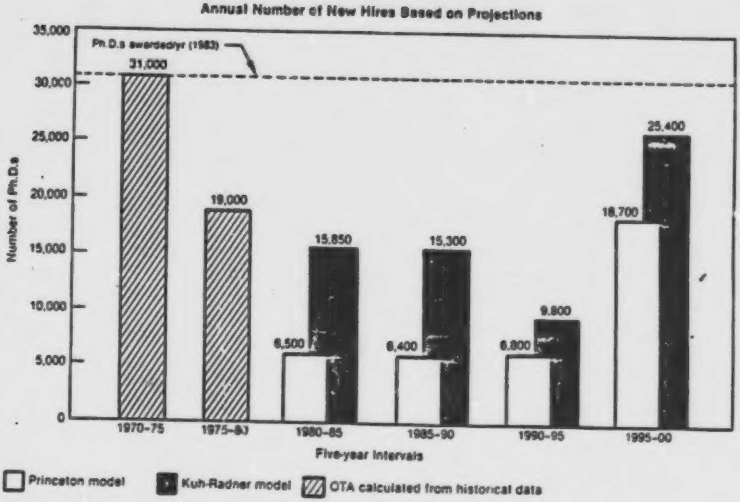
The most significant effect of demographic trends on the scientific and engineering work force comes in the area of faculty appointments for new Ph.D.'s. Here, two demographic forces are at work: changes in the college-age population, and changes in the number of faculty reaching retirement age.

Between 1960 and 1975, the number of faculty employed in U.S. colleges and universities nearly tripled. As a result, more than half of all college professors today were initially appointed in the 1960 to 1975 timeframe. Since that group cannot reasonably be expected to retire until the 1990's, we are in and will continue to be in a period of low faculty retirements until then. This period of low retirements coincides with the period of declining college enrollments projected for 1985 to 1995. Thus student and faculty demographics combine over the next decade to create a very weak demand for new college and university faculty.

The decline in academic positions in the next decade is not a new finding. In fact, it was predicted by a number of analysts in the late 1970's.

Figure 3, which follows page 7 in your text, summarizes the projections of two teams, that of Charlotte Kuh and Roy Radner in 1978, and President William Bowen of Princeton University in 1981. With some differences both project a significant weakening in the number of new academic hirings over the 1980 to 1995 time period followed by a recovery in 1995 to 2000.

[The chart follows:]



SOURCES: William G. Bowen, *Report of the President* (Princeton, NJ: Princeton University, April 1981), p. 20, and C. Kuh and R. Radner, *Preserving a Lost Generation* report to the Carnegie Council on Policy Studies in Higher Education, October 1978, p. 40.

FIGURE 3

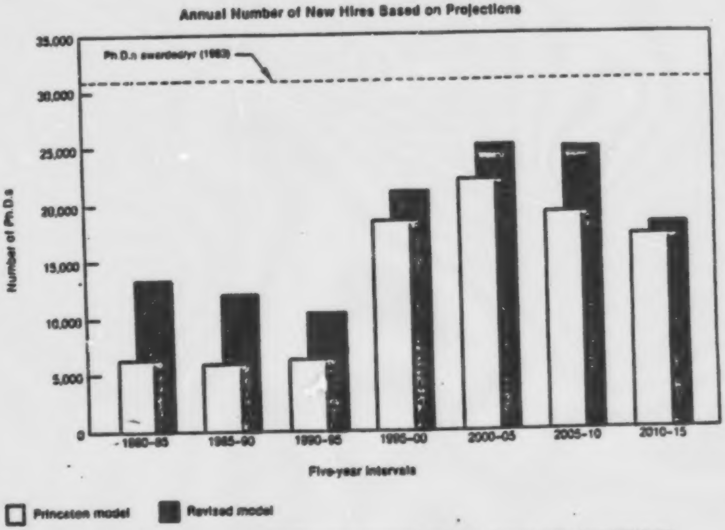
When these results were made public a number of educational groups expressed concern over their implications. The National Academy of Sciences, for example, worried that: first, the rate of research innovation, the inflow of new ideas, and the vitality of the research effort will be impaired; second, that continuity in education and socialization of succeeding generations of researchers will be threatened; and third, the perceived lack of opportunity for an academic career may discourage able and creative young people from pursuing careers in basic scientific research.

Despite these cries of alarm, nothing has been done since the late 1970's to address the problem of the vanishing job market in academia for new Ph.D.'s. One of the reasons for this is the great difficulty in devising policy options that are consistent with the limited role of the Federal Government in providing support for faculty. Especially in an era of tight budgets, could the Government conceivably be justified in paying the universities to hire people they don't need just to ensure an adequate supply of jobs for new Ph.D.'s.?

One promising approach that has been taken on a voluntary basis by a number of universities in the State of New York is to offer incentives for early retirement to senior faculty. If structured carefully, this approach can potentially free up funds and positions to hire new junior faculty. It will be worthwhile for the National Science Foundation or some other group to monitor this new development, try to determine which early retirement incentives work best, and disseminate the results of successful programs to other universities to emulate.

To look at longer term trends, OTA extended the analysis of the academic labor market beyond the year 2000, where most previous studies stopped, to the first decade and a half of the 21st century. The results are shown in figure 4, which follows page 8 in your text. As you can see, our analysis projects a considerable rebound in the academic demand for new faculty in the period 1995 to 2015, at a level roughly equal to that of the late 1970's.

[The chart follows:]

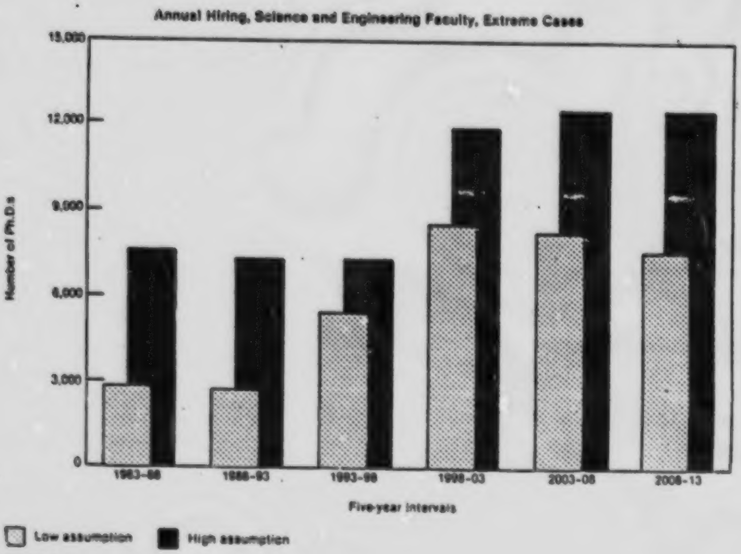


SOURCES: William G. Bowen, *Report of the President* (Princeton, NJ: Princeton University April 1981); and Office of Technology Assessment analysis.

FIGURE 4

OTA then looked at science and engineering in particular, using data from the NSF on the age distribution of doctoral scientists and engineers employed at 4-year colleges and universities. Sample results of our analysis of the scientific and engineering population are presented in figure 5, which follows page 9.

[The chart follows:]



SOURCE: Office of Technology Assessment

FIGURE 5

In the two cases shown, which represent extreme high and low values, academic hiring of new science and engineering Ph.D.'s dips to one-third to four-fifths—one-third in the low case, four-fifths in the higher case—of its 1982 level, which was about $8,500 per year in the 1983 to 1993 time period and then rises to match or exceed its 1982 level from 1998 to 2013.

It should be stressed that these simulations contain a great deal of uncertainty over the effect of factors such as enrollments, Federal research budgets, quit rates, and retirement rates on the actual hiring behavior of universities. Therefore, this should be taken only as indicators of likely future trends.

The National Research Council has obtained a copy of the OTA model with the intention of rerunning it in the future using a variety of assumptions about the input parameters. It appears that the National Science Foundation is interested in providing NRC with the resources to carry out such studies, and they are quite welcome.

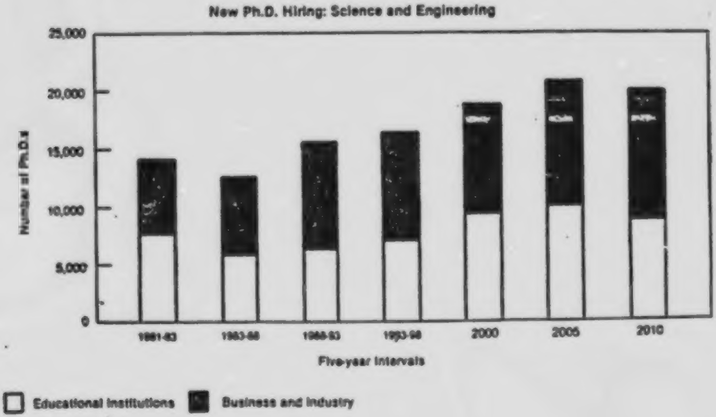
It is important to discuss one final phenomenon—a recent one—that could have an important effect on the overall market for science and engineering Ph.D.'s. The number of Ph.D. scientists and engineers employed in industry has increased dramatically in the past decade, more than doubling between 1973 and 1983. The increases have been especially great in computer science, psychology, and social science, but have been significant in all fields.

In addition to hiring for performance of research and development, industrial employers have also dramatically increased the numbers of science and engineering Ph.D.'s utilized in consulting, sales, and professional services. According to OTA analysis, the number of new science and engineering Ph.D.'s hired by industry in the 1981 to 1983 time period exceeded the number hired by colleges and universities for the first time in recent history.

If these trends continue, the strong industrial demand for new Ph.D. scientists and engineers over the next decade could compensate for the weak academic demand projected for that same era.

In the late 1990's and the first decade of the 21st century, we could witness stiff competition between industry and academia for a limited number of new science and engineering Ph.D.'s. These trends are illustrated in figure 6, which follows page 10. Unfortunately, we do not have a clear idea of why the number of industrial scientific and engineering Ph.D.'s increased so dramatically between 1973 and 1983. A study of the causes of recent trends in industrial employment of Ph.D. scientists would be a timely and valuable one.

[The chart follows:]



SOURCE: Office of Technology Assessment.

FIGURE 6

In summary, OTA finds the following relationships between demographic trends and the scientific and engineering work force. The projected decline in the college-age population will not necessarily lead to shortages of science and engineering bachelor's or Ph.D. degrees. This is so principally because career choices and market forces have a greater effect on the supply of scientists and engineers than does demographics. The near-term decline in the number of 18- to 24-year-olds does imply, however, that existing efforts to promote opportunities in science and engineering among women and certain disadvantaged minority groups need to be strengthened.

Finally, due to a combination of student and faculty demographics, the near-term market for science and engineering Ph.D.'s in academia should be quite weak over the next decade. If this weak market discourages students from pursuing research careers it could lead to serious problems in the late 1990's and early 21st century when a strong rebound in demand is likely to occur.

Thank you, Mr. Chairman. I will be very happy to answer any questions you have at this time.

[The prepared statement of Dr. Frankel follows:]

STATEMENT OF DR. EUGENE FRANKEL

Project Director
Accompanied by John Andelin, Assistant Director
Science, Information, and Natural Resources Division
and
Nancy Carson Naismith, Program Manager
Science, Education, and Transportation Program
Office of Technology Assessment

Before the House Committee on
Science and Technology
Science Policy Task Force

DEMOGRAPHIC TRENDS AND THE SCIENTIFIC AND ENGINEERING WORK FORCE

February 19, 1986

TESTIMONY OF DR. EUGENE FRANKEL, SENIOR ANALYST

TO THE

HOUSE COMMITTEE ON SCIENCE AND TECHNOLOGY

SCIENCE POLICY TASK FORCE

February 19, 1986

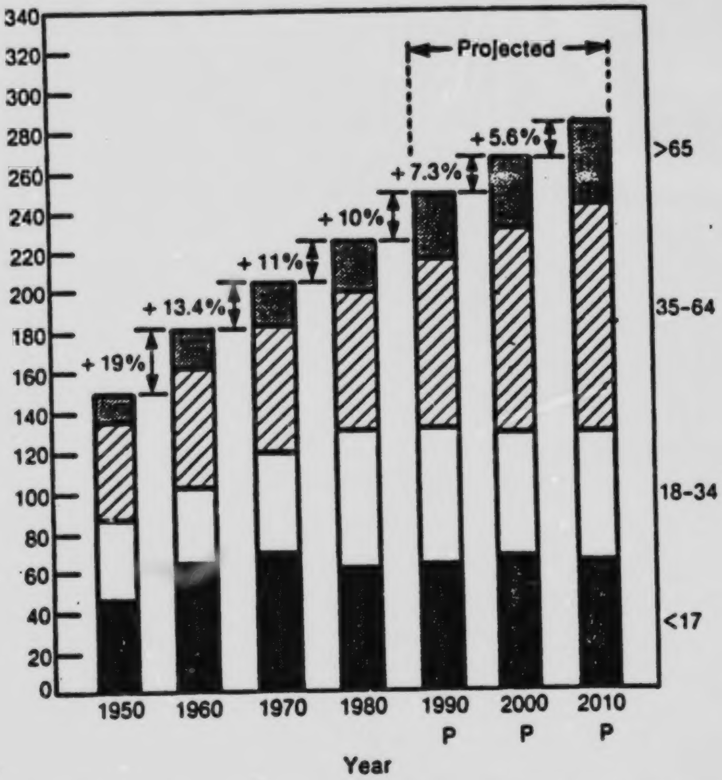
The key role of the Federal Government in educating and assuring an adequate supply of scientists and engineers has been acknowledged since the close of World War II. Scientists and engineers represent only 3.5 percent of the national work force, but are considered to be a crucial element in the Nation's efforts to improve its economic competitiveness and national security. The Office of Technology Assessment was asked by the Task Force on Science Policy of the House Committee on Science and Technology to examine the implications of long term demographic trends for scientific and engineering personnel policy, and to consider as well the barriers to and future trends in the participation of women and minorities in scientific and engineering careers. I am pleased to be with you today to present some of the findings of that study.

Demographics and the Possibility of Future Shortages

Figure 1 shows historical and projected population changes for the U.S. as a whole from Census Bureau figures (middle series), between 1950 and 2010. As can be seen, the

FIGURE 1

U.S. Population by Major Age Groups, 1950-2010



SOURCE: *Projections of the Population of the United States, by Age, Sex and Race: 1983 to 2080*, series P-25, No. 952 (Washington, DC: U.S. Department of Commerce, Bureau of the Census, May 1984), table E, p. 7.

overall rate of population growth decreases from decade to decade, and the fraction of the population in the 35 to 64 and over 65 age brackets increases dramatically over the next 25 years.

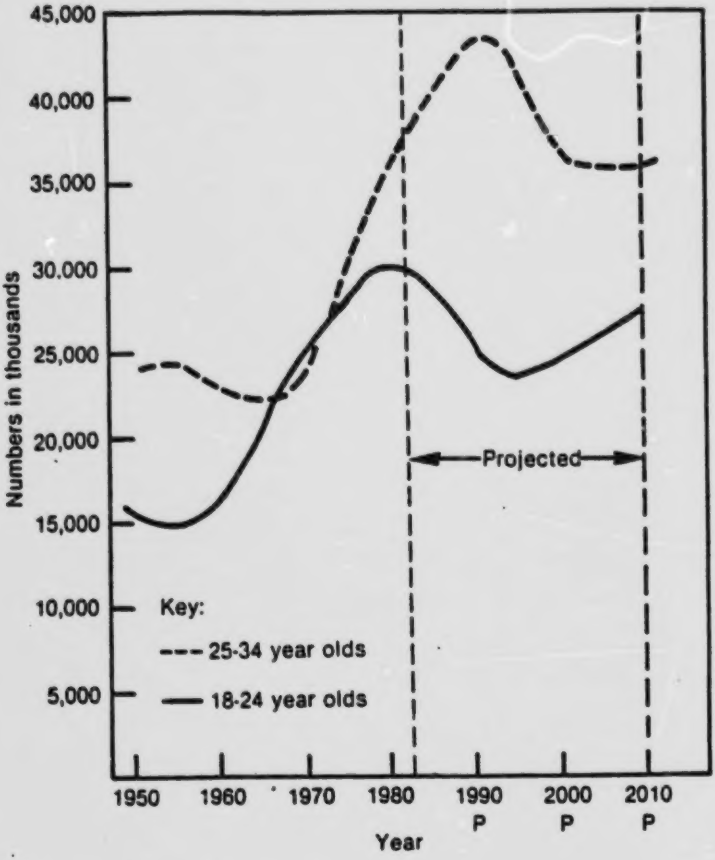
Figure 2 shows the projections for two populations of special interest to this study: the 18 to 24 year olds who form the bulk of the college age population and the 25 to 34 year olds who contribute the lion's share of graduate students. As can be seen, the size of the 18 to 24 year old group doubled between 1960 and 1980, and is now experiencing a fairly significant decline. This drop should end in 1995 and be followed by a modest recovery. The 25 to 34 year old group has been growing since 1970 and will continue to do so through the early 1990s. The peak in about 1995 will be followed by a small decrease through the year 2000 and then a leveling off in the first decade of the 21st century.

As most students receive their BA at age 22 and the Ph.D. at age 30, the first concern raised by these demographic trends is whether the projected near-term drop in the number of 18 to 24 year olds, and longer-term decline in 25 to 34 year olds, could result in shortages of science and engineering baccalaureates and Ph.D.s. If, as has been argued, the Nation will require an increasing number of scientists and engineers to meet its national security, economic growth and technological innovation requirements, this possible decline in science and engineering degrees could pose a significant problem. Fortunately, OTA finds this scenario to be unconvincing, for several reasons.

On the undergraduate level, it is entirely possible that the number of people trained in science and engineering will not decline at all, despite the drop in the college age population. This is possible for several reasons. First, the decline in enrollment may not occur. The proportion of 25 to 44 year olds who attend college, and whose population cohort will not be decreasing, has increased dramatically in the past decade, especially among women. The number of foreign nationals attending U.S. colleges and universities has increased more than ten-fold in the past thirty years, and many remain here after

FIGURE 2

18-24 Year Olds and 25-34 Year Olds in the U.S. Population, 1950-2010



NOTE: Figures for 1983 to 2010 are projected.

SOURCE: *Projections of the Population of the United States, by Age, Sex and Race: 1983 to 2080*, series P-25, No. 952 (Washington, DC: U.S. Department of Commerce, Bureau of the Census, May 1984) table E p. 7.

completing their education. If increases in college attendance of 25 to 44 year olds and foreign nationals continue over the next decade, they could compensate in part for the decline in the total number of 18 to 24 year olds.

Second, there could be increases in the rate at which college students choose to major in science and engineering. Currently, the fraction of 22 year olds receiving a bachelor's degree in a science or engineering field is near the low point of the last decade. A slight increase in the rate of selection of science and engineering careers among college age students could more than compensate for the decline in 18 to 24 year olds projected for the 1982 to 1995 time frame. Projections of shortage might well serve to increase science and engineering enrollments, as the labor market responds by promising increased pay or better job opportunities.

Third, science and engineering workers can be obtained by employing a higher proportion of those obtaining the required undergraduate degrees, and drawing on the existing talent pool. Less than two-thirds of the science and engineering baccalaureates produced in recent years have actually become part of the science and engineering work force.

Finally, on the graduate level, there appears to be no direct relationship between the number of Ph.D.s in science and engineering and the size of the graduate school age population. Between 1960 and 1970, for example, the number of full-time graduate science and engineering students enrolled in U.S. institutions of higher education increased 150 percent, and the number of science and engineering Ph.D.s awarded increased nearly three-fold. At the same time the population of 25 to 34 year olds — the group that supplies the majority of graduate students — barely increased. Accordingly, the size of the 25 to 34 year old age cohort does not appear to be closely linked to the supply of science and engineering Ph.D.s.

It is important to remember that there is no national market for scientists and engineers as a group. Rather, there are specific markets for graduates trained in particular disciplines, and these markets and disciplines can experience very different conditions at the same time. For example, the NSF projected in 1982 that the demand for electrical and aeronautical engineers and for computer specialists could exceed the supply of graduates in those fields over the next five years. At the same time the NSF projected that there would be surpluses of trained biologists, chemists, geologists, physicists, mathematicians, chemical, civil, and mechanical engineers. **It is individual disciplines, especially those linked with high growth or defense-oriented industries, that could experience personnel problems in the future; not "science and engineering" as a whole.**

This finding is encouraging, because individual disciplines have shown great ability to grow and shrink as market conditions require. The number of engineering baccalaureates, for example, more than doubled between 1976 and 1984. The number of computer and informational science B.A.s tripled between 1977 and 1982. At the same time B.A.s in education, foreign languages, anthropology, history, and sociology all fell significantly. Thus college students appear to be highly responsive to market signals, and appear to shift their career choices dramatically toward fields that promise greater occupational rewards. **OTA concludes that career choices and market forces have a greater impact on the supply of scientists and engineers than does demographics.**

Demographics and Equality of Opportunity

OTA finds that the changing college student demographics of the coming decade have several important implications for national policy to promote equality of opportunity in science and engineering as set forth in the Equality of Opportunities in Science and Technology Act of 1981, passed by Congress in part on the initiative of this Committee. If the science and engineering work force is to be sustained, it will become especially important to utilize all potential human resources to the fullest extent possible. This means that increasing attention should be paid to those groups with historically low participation rates in science and engineering, such as women and some minorities. The increasing fraction of college students that will be drawn from the black and Hispanic populations, who have historically participated in science and engineering education and employment at far lower rates than the white population, implies that programs aimed at increasing the participation of these two minority groups could be an especially important source of new talent.

In order to understand what will be required it is important first to have a clear picture of the factors leading to reduced participation by women and certain minority groups in science and engineering. These factors include:

- the continuing legacy of decades of discrimination and discouragement from scientific careers,
- differential treatment, especially of women, but also of minorities, in the science and engineering work force,
- lack of early educational opportunities among minorities due to economic, social, and cultural factors,
- female socialization patterns that discourage young women from perceived "masculine" careers,
- expectations that women will continue to assume the major role in housekeeping and childrearing, and sacrifice their professional interests to those of their husband,
- lack of financial support for and institutional biases against minorities in the higher education system,
- lack of role models and early exposure to science and engineering as worthwhile and accessible careers.

Obviously many of these factors reflect broader social problems which cannot be remedied by science policy alone. However, there is considerable evidence that special science education programs for women and minorities, especially at the junior high and high school levels, can compensate to some degree for the disadvantages experienced by these groups. A 1984 report on Equity and Excellence by the American Association for the Advancement of Science recommends several attractive options to remedy this problem:[1]

> Federal support for programs to improve the quality of pre-college education in science, mathematics, and technology should require that proposals specifically address themselves to plans for serving women, minority, and disabled student populations.
>
> Federally supported programs for teacher training and retraining should require that teaching methods and career and equity aspects be included, along with a rigorous focus on improving competence in subject control.
>
> The Federal Government should support dissemination of models previously shown to be effective in improving science and mathematics education for women and minorities. . .
>
> . . . previously supported programs that had a strong positive educational impact on women and minorities should be re-examined for possible reinstitution.

It should be noted that the lower participation in scientific and engineering careers among blacks, Hispanics, and American Indians does not extend to all minority groups. Asian Americans in particular are participating in science and engineering education in record numbers and are doing very well at it. Numerous hypotheses have been proposed to explain this phenomenon, but these have not been fully verified, and this field would benefit from further study.

Demographics and the Academic Market for new Science and Engineering Ph.D.s

The most significant effect of demographic trends on the scientific and engineering work force comes about in the area of faculty appointments for new science and engineering Ph.D.s. Here two demographic forces are at work: changes in the college-age population and changes in the number of faculty reaching retirement age. Between

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[1] Shirley M. Malcom, et al., Equity and Excellence: Compatible Goals (Washington, DC: American Association for the Advancement of Science, December 1984), p. 30.

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1960 and 1975 the number of faculty employed in U.S. colleges and universities nearly tripled. As a result, more than half of all college professors on the Nation's campuses today were initially appointed in the 1960-1975 period. Since that group cannot reasonably be expected to retire until the late 1990s, we are in and will continue to be in a period of low faculty retirements until then. This period of low retirements coincides with the period of declining college enrollments projected for 1985 to 1995. Thus student and faculty demographics combine over the next decade to create a very weak demand for new college and university faculty.

The decline in academic positions available to new Ph.D.s in the 1980s and early 1990s is not a new finding. In fact, it was predicted by a number of analysts in the late 1970s and was the subject of considerable discussion in academic circles in that era. Figure 3 summarizes the projections of two analytical teams, that of Charlotte Kuh and Roy Radner in 1978 and President William Bowen of Princeton University in 1981. With some differences both project a significant weakening in the number of new academic hirings over the 1980 to 1995 time period followed by a recovery in 1995 to 2000.

When these results were made public a number of educational groups expressed concern over their implications. The National Academy of Sciences worried that with fewer new faculty being appointed:[2]

> 1. The rate of research innovation, the inflow of new ideas, and the vitality of the research effort will be impaired;
>
> 2. continuity in the education and socialization of succeeding generations of researchers will be threatened; and
>
> 3. the perceived lack of opportunity for an academic career may discourage able and creative young people from pursuing careers in basic scientific research.

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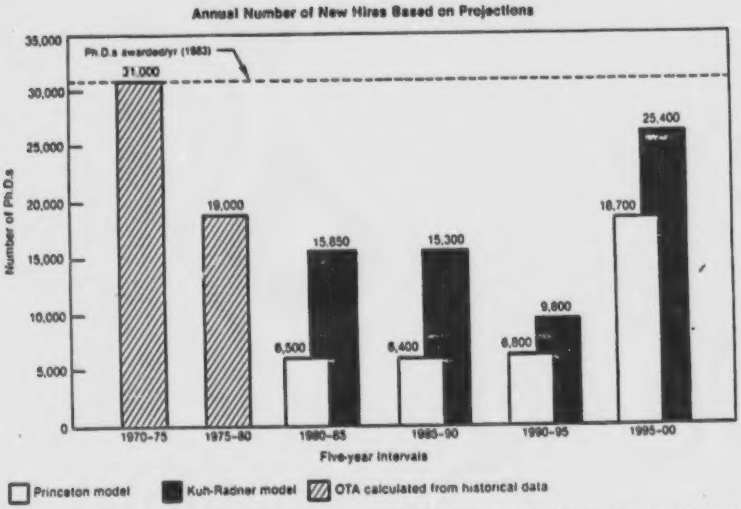
[2] National Research Council, Research Excellence Through the Year 2000 (Washington, DC: National Academy of Sciences, 1979), p. vi.

FIGURE 3



SOURCES: William G. Bowen, *Report of the President* (Princeton, NJ: Princeton University, April 1981), p. 20, and C. Kuh and R. Radner, *Preserving a Lost Generation* report to the Carnegie Council on Policy Studies in Higher Education, October 1978, p. 40.

The Carnegie Council on Policy Studies in Higher Education pointed out that:[3]

> The tenured professionals in 4-year colleges will keep on aging, with the ages of the modal[4] group rising from 36 to 45 in 1980 to 56 to 65 in 2000. This will increase the age gap between students and faculty, raise the average cost of faculty salaries and make it hard to introduce new fields, new courses, new subject matter.

Despite these cries of alarm, nothing has been done since the late 1970s to address the problem of the vanishing job market in academia for new Ph.D.s in the 1980s and 1990s. One of the reasons for this is the great difficulty in devising policy options that are consistent with the limited role of the Federal government in providing support for faculty. Especially in an era of tight budgets, could the government conceivably be justified in paying the universities to hire people they don't need just to ensure an adequate supply of jobs for new Ph.D.s? In some areas of the country the private sector has taken a lead role in providing funds for endowed chairs and other forms of faculty support. Another promising approach that has been taken on a voluntary basis by a number of universities and the State of New York is to offer incentives for early retirement to senior faculty. If structured carefully this approach can potentially free up funds and positions to hire new junior faculty. It would be worthwhile for the National Science Foundation to monitor this new development, try to determine which early retirement incentives work best, and disseminate the results of successful programs to other universities to emulate.

To look at longer term trends, OTA extended the analysis of the academic labor market beyond the year 2000, where most previous studies stop, to the first 15 years of the 21st century. Using a modification of one of the simpler simulation models developed in the early 1980s, and Census Bureau middle series projections of births and deaths, OTA obtained the results shown in Figure 4 below. As you can see this method

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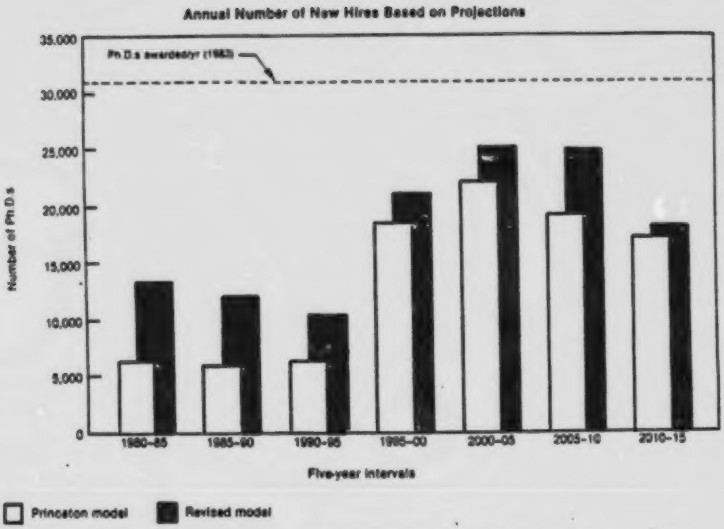
[3] Carnegie Council on Policy Studies in Higher Education, Three Thousand Futures: The Next Twenty Years for Higher Education (San Francisco, CA: Jossey Bass, 1980), p. 80.

[4] The "modal group" is that age group within the overall faculty population distribution that contains the largest number of individuals.

FIGURE 4



SOURCES: William G. Bowen, *Report of the President* (Princeton, NJ: Princeton University April 1981); and Office of Technology Assessment analysis.

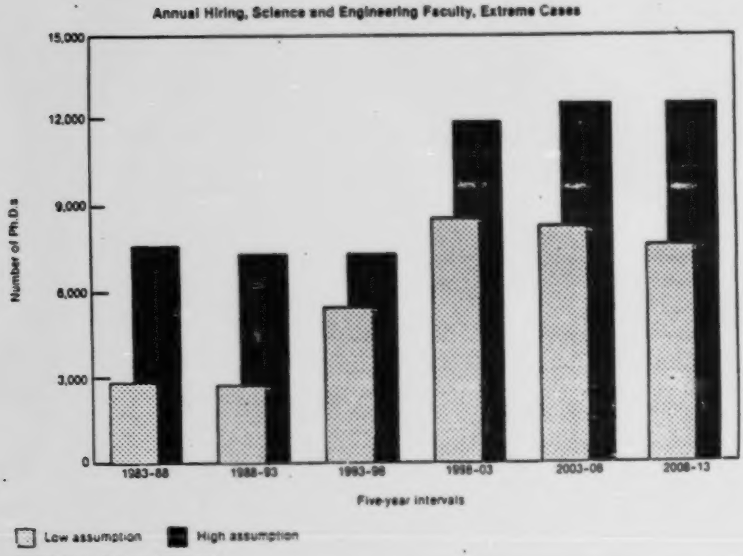
projects a considerable rebound in the academic demand for new faculty in the period 1995 to 2015, at a level roughly equal to that of the late 1970s. (Approximately 20,000 new academic appointments per year.)

OTA then looked at science and engineering in particular, applying this model to the most recent data from NSF on the age distribution of doctoral scientists and engineers employed at 4-year colleges and universities. Using 1983 as a base year, this model projected the number of new junior faculty appointments that would be made at 5-year intervals from 1983 to 2013 under different assumptions about retirements, resignations and enrollments in science and engineering courses. Two simulations developed using high and low values of the input parameters are presented in Figure 5. In the two cases academic hiring of new science and engineering Ph.D.s dips to one-third to four-fifths its 1982 level (of about 8,500 per year) in 1983 to 1993 and then rises to match or exceed its 1982 level from 1998 to 2013.

It should be stressed that these simulations contain a great deal of uncertainty over the effect of factors such as enrollments, Federal research budgets, quit rates, and retirement rates on the actual hiring behavior of universities. Therefore they should be taken only as indicators of likely future trends. The National Research Council has obtained a copy of the OTA model with the intent of re-running it in the future using a variety of assumptions about the input parameters. It appears that the National Science Foundation is interested in providing NRC with resources to carry out such studies.

It is important to discuss one more phenomenon -- a recent one -- that could have an important effect on the overall market for science and engineering Ph.D.s. The number of Ph.D. scientists and engineers employed in industry has increased dramatically in the past decade, more than doubling between 1973 and 1983. The increases have been especially great in computer science, psychology and social science, but have been significant in all fields. In addition to hiring for the performance of research and development, industrial employers have also dramatically increased the numbers of

FIGURE 5

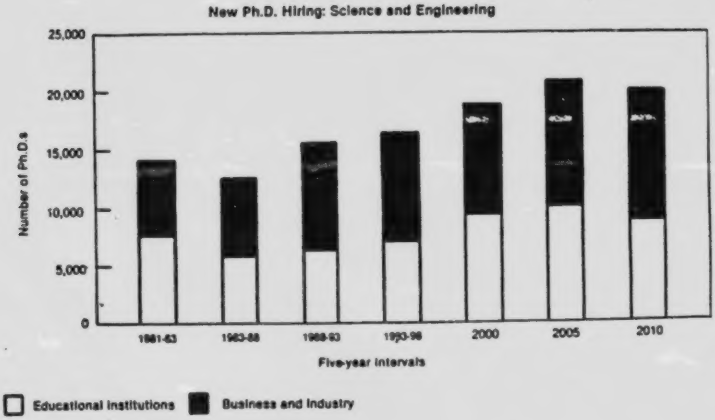


SOURCE: Office of Technology Assessment

science and engineering Ph.D.s utilized in consulting, sales, and professional services. According to OTA analysis, the number of new science and engineering Ph.D.s hired by industry in the 1981 to 1983 time period exceeded the number hired by colleges and universities for the first time in recent history.

If these trends continue, the strong industrial demand for new Ph.D. scientists and engineers over the next decade could compensate for the weak demand projected for academia. In the late 1990s and first decade of the 21st century we could witness stiff competition between industry and academia for a limited number of new science and engineering Ph.D.s. These trends are illustrated in Figure 6 below. Unfortunately, we do not have a clear idea why the number of industrial scientific and engineering Ph.D.s increased so dramatically between 1973 and 1983. A detailed study of the causes of recent trends in the industrial employment of Ph.D. scientists and engineers would be a timely and valuable one.

In summary OTA finds the following relationships between demographic trends and the scientific and engineering work force. The projected decline in the numbers of 18 to 24 and 25 to 34 year olds will not necessarily lead to shortages of science and engineering bachelor's or Ph.D. degrees. This is so principally because career choices and market forces have a greater effect on the supply of scientists and engineers than does demographics. The near-term decline in the total number of 18 to 24 year olds does imply however that existing efforts to promote opportunities in science and engineering among women and certain disadvantaged minority groups need to be strengthened. This finding is reinforced by the fact that an increasing percentage of the 18 to 24 year old population will be minority groups that are currently underrepresented in science and technology. Finally, due to a combination of student and faculty demographics, the near-term market for science and engineering Ph.D.s in academia should be quite weak over the next decade. If this weak market discourages students from pursuing research careers it could lead to serious problems in the late 1990s and early 21st century when a strong rebound in demand is likely to occur.



SOURCE: Office of Technology Assessment.

FIGURE 6

DISCUSSION

Mr. **Fuqua**. Thank you very much, Gene.

On the last point that you made, and I guess going back even to page 7 where you were talking about the change in demographics, between, I guess it was, the Princeton study, that significant weakening of new academic hirings from 1980 to 1995, and then followed by recovery from 1995 to 2000, and then the last part on page 10 that you were talking about that would be quite weak, are you speaking there, as you say, science and engineering Ph.D. or in academia? How does it look in industry?

Dr. **Frankel**. Well, again, we've seen a tremendous increase——

Mr. **Fuqua**. You've seen a tremendous increase in——

Dr. **Frankel** [continuing]. A real increase——

Mr. **Fuqua** [continuing]. In 10 years——

Dr. **Frankel** [continuing]. A doubling in 10 years.

Now, if that doubling were to continue, well, we'd have a very robust market for science and engineering Ph.D.'s over the next decade. The important point is that we don't understand why the doubling took place between 1973 and 1983. It may be that industry was simply making up for lost time.

There had been a very significant decline in the rate at which industry hired Ph.D.'s between 1960 and 1973, partly because the academic market was so good and was competing very strongly. So it may just be that industry was catching up, or it may be there's some new trend in industry, and this will continue. Obviously——

Mr. **Fuqua**. Do you have any studies in that——

Dr. **Frankel**. No, I——

Mr. **Fuqua** [continuing]. That field?

Dr. **Frankel**. I asked the National Science Foundation, the National Academy of Sciences, if anybody could tell me why this phenomenon had occurred; and people had guesses as to the causes, but I don't think anybody has tried to do an indepth study of industry to find out why there has been this dramatic increase in their hiring of science Ph.D.'s. Some think it's just because the academic market has been so weak lately that science and engineering Ph.D.'s are looking more aggressively outside of academia and——

Mr. **Fuqua**. Hasn't there been a general trend in industry for more expenditures in research areas?

Dr. **Frankel**. Yes; that's right, there has. And there's also been a trend in the Nation as a whole that the science and engineering work force——

Mr. **Fuqua**. So whatever influence about a tax law, but that was——

Dr. **Frankel**. Right——

Mr. **Fuqua**. That's been really recent and that——

Dr. **Frankel**. Yes.

Mr. **Fuqua**. I think you're using a base period of 1973 to 1983.

Dr. **Frankel**. Right. Yes, there's been quite an increase in industrial research and development expenditures in that period.

Mr. **Fuqua**. But that's been since 1980, 1981 I guess that that law came into being.

Dr. **Frankel**. Right. Right. And the increase had begun, I think, before 1980——

Mr. **Fuqua**. Yes; oh, yes, it had.

Dr. **Frankel**. So I would guess that that may be what we are seeing. You may be right, that the increase in hiring of Ph.D. scientists may be a derivative of the increase in the budgets that industry is spending. But, as I point out in the text, the interesting phenomenon is that many of these people—Ph.D. scientists—are being used in consulting, sales, marketing, not in R&D. So we are seeing them utilized outside of the traditional fields.

Dr. **Fuqua**. You also were talking about the lack of demand in the academic area, in faculty. What will that do to basic research, quality basic research, in our academic institutions?

Dr. **Frankel**. Well, I think the main problem it creates is that undergraduates or people graduating from college perceive that there is no market for Ph.D.'s in academia and therefore don't pursue research careers, so we don't attract the best people into research. I can't say that we'd have a shortage of research scientists, because right now it appears if anything we have a glut. There are more research scientists with good proposals applying to the Federal Government and elsewhere for research assistance than can be funded, so I don't think we are in a shortage situation now. In fact, we can't seem to fund everyone qualified that exists. But, on the other hand, I think the discouragement of pursuing an academic research career could be a significant problem. Now again, if industry now becomes the more desirable target, then perhaps we won't see that problem.

Mr. **Fuqua**. But I'm concerned that you don't get the turnover in the faculty though.

Dr. **Frankel**. That's right, you won't.

Mr. **Fuqua**. And you mentioned the early——

Dr. **Frankel**. You won't.

Mr. **Fuqua** [continuing]. Early out.

Dr. **Frankel**. Well, that seems to be the——

Mr. **Fuqua**. But the engineering enrollment is different from the other sciences. As I understand it, it has been going up——

Dr. **Frankel**. That's right.

Mr. **Fuqua** [continuing]. And there is some figure of 2,000 faculty vacancies right now——

Dr. **Frankel**. Right.

Mr. **Fuqua** [continuing]. In qualified engineering faculty.

Dr. **Frankel**. I think it should be stressed that the statements that I am making are about faculty as a whole, science and engineering faculty as a whole. Different fields are experiencing different conditions at the same time and you are absolutely right.

Engineering certainly has been in a situation where they feel they cannot hire all the new teachers that they need. There are other fields that are in similar situations; computer science is another one.

On the other hand, sociology, physics, and chemistry appear to be in situations of relatively weak academic demand. One of the things that we did not have time to do in the study, which would be very useful to do, would be to look at this field by field and see how the trends work out in each separate field. We've been thinking that that would be a study that would give you a little bit more of a texture of what's actually going on in science and engineering.

Mr. **Fuqua**. It would be very helpful. How long would a study like that take?

Dr. **Frankel**. Well, it would depend on how it was done. If it was limited to that particular topic I think we could do that in about a year. If we wanted to look at it in the context of all of the forces that are impinging on the university, the facilities problem, the equipment problem, the potential cutbacks in R&D budgets, the extreme drop in enrollments in some States, increases in enrollments in other States, if we took a more comprehensive view, we would probably have to do a full 2-year OTA study. But the first study I think would not involve that much effort. It would take 6 or 8 months to form, and then usually the usual 3 or 4 months to go through the review process and get published. We have done most of the background work and we know where the information lies.

Mr. **Fuqua**. We've been very interested in the involvement of women and minorities.

Dr. **Frankel**. I know.

Mr. **Fuqua**. More into the science. Do you have any information on what influences decisions to either go into science and engineering, or maybe the other way around, not to go into it?

Dr. **Frankel**. Yes; we do. And they are different for the different groups. In the case of women, there's a very well-developed literature which we surveyed, and we tried to pull out in the text of the tech memo the main forces that we saw. These are not the only ones, but these seem to be the ones that are the most significant, and they are based in the examination of exactly where women seem to fall out of the science and engineering pipeline most rapidly.

Our finding was that the first major source of discouragement comes from what we call sex-role stereotyping of the work force. There is still a fraction of young girls who perceive, especially in engineering, it as being men's work and don't go into it; just like there is still a fraction of young boys who perceive things like elementary education and nursing, occupational physical therapy as being women's work and don't go into those, and that seems to be one major factor.

Second seems to be the degree to which young women think that they are going to be able to make a commitment to the work force in their early twenties. Those women who are willing to make a full-time commitment to the work force are more likely to select science and engineering careers. Those who want to be able to reserve some time to get married and have a family tend not to want to take on a career that is as demanding as science and engineering in terms of preparation time and full-time work once you are in them.

Mr. **Fuqua**. How does that compare to a field, say, like law?

Dr. **Frankel**. That's an interesting question. Women certainly select law at a higher rate than science and engineering as a whole, and yet law is a fairly demanding field and does require a fairly strong work-force commitment. I have not really thought out why that should be. It may simply be that the engineering part of science and engineering is really the key difference between the men and the women, and that really brings down the statistics. And I would think that if one factored engineering out, it is very likely that if you just took the sciences I think women's participation rates would be about equal to those of women as M.D.'s and law degrees and other professions, which I think ranges about 30 or 40 percent.

I really hadn't thought about that, and I don't know why it should be that different for science and engineering than law because I think you're right that it does require quite a substantial labor-force commitment.

Mr. **Fuqua**. What about minorities?

Dr. **Frankel**. OK, on the minorities level——

Mr. **Fuqua**. You mention that certain minorities, I think you mentioned Asians, had a tendency to go into engineering.

Dr. **Frankel**. Yes; well, the Asians, as we know it, are going into engineering and science in record numbers and they seem to be at the head of the class too. They are doing extremely well and they are using that as their avenue of entry into mainstream American society.

Blacks and Hispanics are having a lot of trouble as are American Indians, and the main problem seems to be lack of preparation in high school—poor preparation in high school. And that in turn seems to be related to parent's educational levels.

It is a very interesting statistic that it turns out that when the parents of a black, or a Hispanic, or an American Indian are college graduates themselves the children tend to select quantitative fields at exactly the same rate as whites do. So being second generation college seems to eliminate all the differences that we see between blacks and Hispanics and whites.

On the other hand, we know that from many inner city kids growing up in the ghettos, they simply start off their life with poor education, in part because of what's going on in their family and in their neighborhood, and they just don't have a quiet home to come to to study. They don't have parents who encourage study. They don't have all of the props that we middle-class professionals tend to give to our children to become well-educated.

And of course science and engineering careers are critically dependent on getting a good, early education, especially in mathematics. Many of these children aren't even told that there is such a thing as a scientific career or that mathematics is important for it. So they effectively don't even get the chance to opt into science because they don't make the early preparation required. And I think that may be one of the differences between science and law that we were talking about earlier.

In law, you can probably decide you want to get a law degree. You can major in almost anything in college and then decide at the end that you want to get a law degree. In quantitative science fields you have to make at least a commitment to take enough mathematics in high school that you can pursue the careers in college, so that the labor force participation issue for the women when they are teenagers and thinking about what they are going to do with the rest of their life becomes more important. So that many young women who reach college and then discover that, "Oh, yes, I really do want to have a job; in fact, would like to be a kind of professional," can't go back and take all the background mathematics that they would have to take to pursue a career in physics. But they can pick up law because law doesn't require a specialized training until you actually go to law school.

Mr. **Fuqua**. We had some testimony last year sometime about making choices that went back to 8 through 12, and really, at about the 9th- or 10th-grade level. Students had to make a choice——

Dr. **Frankel**. That's right.

Mr. **Fuqua** [continuing]. Whether they wanted to continue with—because they had taken maybe only 1 year of required science or math or both——

Dr. **Frankel**. Right.

Mr. **Fuqua** [continuing]. And that was about up at that time, and if there was not further requirement for graduation for science, and so forth, then you were inadequately prepared to pursue that once you got to college. And it was very important in this person's testimony that curriculum requirements be such that they extended the amount of math and science required in probably the junior/senior year in high school because a lot of people, if you're 13, 14, 15 years old, you probably have other things on your mind——

Dr. **Frankel**. Right.

Mr. **Fuqua** [continuing]. At that age than studying calculus or algebra or basic physics.

Dr. **Frankel**. I think we at OTA would heartily endorse that recommendation; that we not let people opt out of science and mathematics without having thought about it. It also explains, by the way, why these education programs—special science and mathematics education programs—on the junior high and high school level are so effective; because it takes kids who have not been exposed to science and math and gives them a chance to see what they are all about, and gives them a chance to see that maybe it's something they like so that they make a decision to stay in the mathematics sequence and the science sequence that they need in high school. And I think that's the important thing, not to let kids decide not to major in science simply because they didn't take the background work, because they hadn't even thought about it.

Mr. **Fuqua**. Mr. Packard.

Mr. **Packard**. You indicated in your studies that there will be—particularly in the next 10 years or more— a greater trend to high school graduation and even post graduate work in the Sun Belt areas——

Dr. **Frankel**. Yes.

Mr. **Packard** [continuing]. In comparison to the winter or Frost Belt areas. Has that been related to specific States in terms of those States that have a greater high school graduation? Will there be a greater amount doing post high school work, and even projecting into the engineering fields, to have studies that show that they will remain in those States after high school in their educational career?

Dr. **Frankel**. Well, if we had an overhead projector plugged in I could show you an interesting map on that. This really relates to larger demographic trends in the society. The population growth has been quite large in the Sun Belt and consequently the number of high school graduates is expected to increase dramatically in States like Texas, Oklahoma, Utah, Nevada, Arizona, Florida, while at the same time it's supposed to decrease dramatically in the Midwest, Northeast, North-Central and Mid-Atlantic regions of the country simply because fewer people are there.

Mr. **Packard**. You're talking about numbers there now——

Dr. **Frankel**. Yes.

Mr. **Packard**. But you're also referred to in percentages which I think——

Dr. **Frankel**. Yes.

Mr. **Packard** [continuing]. Indicate that a greater percentage would graduate of the——

Dr. **Frankel**. No; it's not a question that people will graduate high school at a greater rate in those Sun Belt States, simply that there will be more kids graduating high school. And those people do tend—studies show that most people go to college within 150 miles of their hometown—so that those students will tend to stay in the colleges and universities in their States.

Mr. **Packard**. In their States——

Dr. **Frankel**. So especially the State universities will do very well in those States of the West, Far West and Southwest.

Mr. **Packard**. And your demographics show or generally indicate that they will remain in those States, in those Sun Belt States, for their college training?

Dr. **Frankel**. Historically that's what they have done, yes.

Mr. **Packard**. What effect and what do your demographics show in terms of foreign science majors and engineering majors? Are we getting a greater number of foreign students in those fields, and are they staying in the United States and staying within those Sun Belt States?

Dr. **Frankel**. We are definitely getting increasing numbers of foreign students majoring in science and engineering and that's been especially dramatic at the graduate school level. And as you know, in some fields like engineering, the percentage of Ph.D.'s is actually greater than 50 percent who are foreign nationals. Whether that will continue to increase or not I can't tell. I really don't know. But it certainly has increased over the last two decades and it is projected to increase actually by the International Educational——

Mr. **Packard**. Now do your——

Dr. **Frankel** [continuing]. Institute for Educational——

Mr. **Packard**. I think your indications are that industrialized nations also are showing a higher increase in engineering students. Are we attracting more and more of those? Are they coming after graduation, coming to the United States to enter the work force from foreign universities?

Dr. **Frankel**. The foreign students that come here are principally from Southeast Asia, secondarily from the Middle East. The rest of the industrialized world does not contribute that great a share except Canadians who are so close they are our neighbors. There is in my text—there's a breakdown of where the students come from, and overall the lion's share, the biggest contributors seem to be the East Asians and students from the Middle East.

Mr. **Packard**. Do we have more coming from foreign countries and entering into our work force than we have—I assume we would—than we have exporting our own——

Dr. **Frankel**. Yes.

Mr. **Packard** [continuing]. To foreign countries?

Dr. **Frankel**. Yes.

Mr. **Packard**. Considerably more?

Dr. **Frankel**. It's estimated that, I think on the graduate level, about 50 to 60 percent of the foreign students that come in on temporary visas wind up staying here.

Mr. **Packard**. Staying here?

Dr. **Frankel**. And those that come on permanent visas it's over 90 percent.

Mr. **Packard**. Do you have any figures as to how many of our students go to foreign countries for work?

Dr. **Frankel**. No, I don't.

Mr. **Packard**. In the President's proposed budget a recommendation to increase the amount of money earmarked for R&D and for science and the research areas, if in fact that came about, or if there was an increase in the funding levels of R&D work at the Federal level, what effect would that have upon the statistical information you've given us in terms of a greater commitment toward the engineering fields?

Dr. **Frankel**. Well, I think we've found that the graduate level certainly—the enrollments and the degrees—are very responsive to the level of Federal support. Federal support for research translates into Federal support for research assistantships, and the more research assistantships there are, that attracts students into these fields. So I think that it would definitely increase the number of students majoring in science and engineering fields on the graduate level to have an increase in Federal research budget.

Mr. **Packard**. What other factors could be done at the Government level to alter the trends that you've indicated?

Dr. **Frankel**. Well, we did a fairly indepth study of the period from 1960 to 1975 when the Government took a very active role in trying to promote science and engineering education on the graduate level, and graduate education in general, and then pulled out of that role.

We found that Federal support for fellowships and traineeships—which is something that we did on a very large scale in that era—was very effective. It drew a lot of students into the science and engineering work force. And if we ever were in a situation where we needed more students in science and engineering it would be a very effective tool to use.

We found that at the same time, in that same period, it wasn't only the Federal Government that was acting. States and institutions themselves were providing increasing teaching assistantships because they were experiencing greater student loads, because that was the era when many more students were going to college. So we can't say that it was Federal policies alone that explained these—the huge increase in the number of students in the 1960's—but certainly it was a major force in assisting the development of greater number of students in these fields.

Mr. **Packard**. Thank you, Mr. Chairman.

Mr. **Fuqua**. Mr. Lujan.

Mr. **Lujan**. Thank you, Mr. Chairman. Good morning.

Dr. **Frankel**. Good morning.

Mr. **Lujan**. One of the things that kept going through my mind is—as I earlier looked at the report—is one of the conclusions that you've drawn, and that is that market forces determine. I think maybe the decline—because maybe students have not quite gotten over the fact that for a period there we had such a surplus of engineers that they couldn't find a job and so they chose a different career—and that as we move along that will correct itself simply because we're going to need more.

Dr. **Frankel**. Well, it has. That's exactly the experience of the transition from the early 1970's when we had that terribly weak market for engineers and students were staying away from it, to the late 1970's when the market turned around and students started coming in in droves. This doubling of the number of bachelor's degrees in engineering between 1976 and 1984 is a very dramatic trend and one that we haven't seen——

Mr. **Lujan**. The other——

Dr. **Frankel** [continuing]. Too frequently.

Mr. **Lujan** [continuing]. Thing that perhaps might have an influence. Most of your work, it seems, kept a level of the numbers of engineers and scientists that we will need in the future—that 3 percent of the work force that is engineers. I didn't see any indication—maybe it is in there but I missed it—that in the type of society that we are moving into, that certainly that proportion is going to be much higher in terms of scientists and engineers that the country will need.

Dr. **Frankel.** I wish I could tell you that I am sure that it is, but I'm not, I'm really not. Every time one sees a trend in one direction one sees a countertrend in the other direction.

For example, we've seen in microelectronics and in computers this year a considerable slump in the market, and people are laying off in those fields. We thought there was going to be a big boom. Now it seems like it may not be quite so big a boom. We thought there was going to be a huge boom in defense spending. Well, that has had to be moderated as deficit considerations have reduced the amount that Congress has been willing to appropriate for defense.

There tend to be cyclical swings and there tend to be changes in particular fields. New fields develop and they develop very quickly. And one sees rapid growth rates in a small field and then one tends to extrapolate to the entire field of science and engineering and say, "Oh, my goodness, we are going to need double the number of scientists and engineers." But these tend to be fluctuations on what seems to be a much more consistent, much more constant overall long-term pattern. So that I don't think one can prove that, in fact, we are going to become that much more scientific and technological as a society that we are going to need double the number of scientists and engineers.

Ms. **Naismith.** We need more technicians and more technically trained people.

Dr. **Frankel.** Yes. In fact this seems to be an indication that it's the technicians and the technically trained nonscientists that are maybe a more crucial problem than the actual scientists themselves.

Certainly one looks at the academic market which I talked about earlier for Ph.D. scientists and one sees a weakening over the next decade. So it would not be terribly prudent for us to tell young people, "Get your Ph.D. in science where you are guaranteed to have a job," when we know that, in fact, academia is not going to be in a very good position to be hiring them.

Mr. **Lujan.** Matter of fact, it's interesting how things relate to your life. We're in the middle of that sort of thing. My own daughter graduated from George Washington just Sunday and always thought, "Well, I'll go to medical school." Now she's saying, "Hey, that doesn't guarantee you. Maybe I better get my Ph.D. in the field of physics." So we're going through that same thing. Where are the opportunities?

Dr. **Frankel.** I think the important thing with respect to Ph.D.'s is that we were in a situation in the 1960's where people got their Ph.D.'s, and their professors gave them a model of a Ph.D. as somebody who works in the university in research and teaching. And then when it turned out that suddenly the big academic market dried up in the 1970's many people were very disappointed and didn't know what to do.

Now the fact is there is a lot of use for Ph.D.'s outside of universities. Several people sitting here are witness to that fact. And I think if we can begin to get college professors making their students aware of that just because you get a Ph.D. does not mean you should expect an academic career. In fact, there are other things that can be just as challenging, just as interesting, and contribute just as much to your society that you can do with a Ph.D. I think that would be a vast service, because I think a Ph.D. really gives you the flexibility to do lots of different things. We haven't thought of it that way.

In fact, many people get their Ph.D.'s and think of it as a way to get into a very narrow specialty, but in fact it gives you a set of tools that you can use later in life for a variety of things that can be very useful——

Mr. **Lujan**. That's the way we used to think about a B.A. or a B.S. years ago. [Laughter.]

It just escalated. One interesting question that I just had regarding the students here in the United States and those that go out—it seems I saw a chart sometime that about somewhere like 50 percent of graduate engineering students who were foreign nationals——

Dr. **Frankel**. That's correct.

Mr. **Lujan** [continuing]. In the United States, and the interesting part that sometime you might have a look at it—how many of ours go to other countries for their post-degree work?

Dr. **Frankel**. Well, I'm not sure about that. I know that there are many engineering schools—and especially the nonelite engineering schools, schools that aren't MIT or Stanford—that are dying to have American students——

Mr. **Lujan**. The not 10 highest——

Dr. **Frankel**. Right.

Mr. **Lujan** [continuing]. Funded by the National Science Foundation. Oh, we got a little fight going on here. [Laughter.]

And the name of that purpose is like who gets the money.

Dr. **Frankel**. I've heard from several sources that many of these schools would be delighted to have more Americans applying, and that they really are enrolling foreign students simply because most American engineering students would prefer to take their bachelor's degree and go out into industry and get a job immediately and get their reward for their 5 years in engineering education quickly rather than spend the extra 4 of 5 years at the university and get a Ph.D. So I would think that there would be very few Americans who are going abroad to get an engineering Ph.D. because the opportunities here are still quite attractive.

Mr. **Lujan**. Thank you.

Mr. **Fuqua**. Gene, thank you very much for being here. It was a very excellent——

Dr. **Frankel**. Thank you, Mr. Chairman.

Mr. **Fuqua** [continuing]. Report and we'll have to help him think about if we need any additional information beyond the scope of what you've gone into. But its been very, very thorough and very, very helpful and something that we are very concerned about is manpower in the future of this, because without that I think we seriously impede our ability as a Nation to form the type of research necessary as well as continue high quality education. So it is very important.

John, it's good to see you again.

Ms. Naismith, thank you very much for being here.

[Whereupon, at 9:24 a.m., the task force recessed to reconvene on February 20, 1986.]

[Questions and answers for the record follow:]

QUESTIONS FOR THE RECORD

Dr. Eugene Frankel

1. In the OTA study it is noted that in the period between now and year 2000, the "Sun Belt" states will experience a very large growth in the number of high school graduates (i.e. Florida: 20%, Texas: 19%, New Mexico: 11%, California: 18%). In the same period the "Frost Belt" states will experience significant drops in the number of high school graduates (i.e. Michigan: 30%, New York: 28%, Pennsylvania: 28%). What data do we have about the fraction of a state's high school graduates who do go to college, do so in the same state. How many go to college out of state? What, in your view, are the implications for Federal policy with respect to the support of scientific research at our universities?

1. The National Center for Education Statistics publishes, in its annual Digest of Educational Statistics, data on the residence and migration of newly enrolled students in institutions of higher education, by state. A copy of the table from the 1983-1984 Digest is attached as table 1. Column 6 gives the ratio of the number of new students enrolled in a given state who are residents of that state to the total number of students from that state who are newly enrolled in higher education throughout the Nation. As you can see, 87 percent of the domestic U.S. students newly enrolled in higher education are attending a college or university in their home state. That percentage is up from 83 percent in 1975. According to the American Council on Education 1984-85 Fact Book on Higher Education, 88 percent of the students in public institutions and 64 percent of those in private institutions were enrolled "in-state" in 1975. Table 2, also attached, provides a breakdown by state of the percentage "in-state" enrollments in public and private institutions in 1975.

It is not clear that the wide variation in enrollment trends among the states over the next twenty years will have any significant implications for Federal research policy, since Federal research grants and contracts are awarded primarily to principal investigators based on merit. States in areas of declining enrollment may need additional support for maintaining research facilities and equipment and meeting overhead costs as their student-generated revenues decline. States in regions of increasing population may seek Federal assistance for building and equipping new laboratories for their increasing body of research professors.

TABLE 1

Table 73.—Residence and migration of all new students [1] in institutions of higher education, by State: Fall 1981

State or other area	Students enrolled in State [2]	Student residents of State [3]	Students remaining in State [4]	Ratio of students remaining to—		Migration of students		
				Students enrolled	Student residents	Out of	Into	Net (col 8 – col 7)
1	2	3	4	5	6	7	8	9
United States	4,314,437	4,212,734	3,664,643	.85	.87	548,091	649,794	[5]101,703
Alabama	53,795	49,194	43,862	.82	.89	5,332	9,933	4,601
Alaska	3,237	5,268	2,729	.84	.52	2,539	508	–2,031
Arizona	87,109	70,104	63,929	.73	.91	6,175	23,180	17,005
Arkansas	26,996	27,435	23,142	.86	.84	4,293	3,854	–439
California	663,565	626,622	598,662	.90	.96	27,960	64,903	36,943
Colorado	56,736	52,904	43,997	.78	.83	8,907	12,739	3,832
Connecticut	61,122	71,161	50,900	.83	.72	20,261	10,222	–10,039
Delaware	11,748	11,438	8,090	.69	.71	3,348	3,658	310
District of Columbia	27,206	11,872	8,134	.30	.69	3,738	19,072	15,334
Florida	161,310	145,724	126,091	.78	.87	19,633	35,219	15,586
Georgia	63,102	58,487	49,495	.78	.85	8,992	13,607	4,615
Hawaii	16,235	17,318	13,626	.84	.79	3,692	2,609	–1,083
Idaho	15,646	13,902	10,346	.66	.74	3,556	5,300	1,744
Illinois	248,866	264,772	230,597	.93	.87	34,175	18,269	–15,906
Indiana	83,266	76,414	66,068	.79	.86	10,346	17,198	6,852
Iowa	56,101	51,103	42,777	.76	.84	8,326	13,324	4,998
Kansas	48,239	45,073	38,716	.80	.86	6,357	9,523	3,166
Kentucky	45,547	44,126	37,858	.83	.86	6,268	7,689	1,421
Louisiana	56,471	52,172	47,293	.84	.91	4,879	9,178	4,299
Maine	15,937	17,040	12,823	.80	.75	4,217	3,114	–1,103
Maryland	70,083	78,141	59,759	.85	.76	18,382	10,324	–8,058
Massachusetts	158,067	142,244	121,322	.77	.85	20,922	36,745	15,823
Michigan	162,623	166,126	149,779	.92	.90	16,347	12,844	–3,503
Minnesota	65,247	67,547	54,544	.84	.81	13,003	10,703	–2,300
Mississippi	44,006	42,936	39,330	.89	.92	3,606	4,676	1,070
Missouri	82,342	75,089	64,458	.78	.86	10,631	17,884	7,253
Montana	12,468	13,021	10,179	.82	.78	2,842	2,289	–553
Nebraska	35,575	34,701	30,242	.85	.87	4,459	5,333	874
Nevada	12,661	13,979	10,880	.86	.78	3,099	1,781	–1,318
New Hampshire	17,620	16,410	10,644	.60	.65	5,766	6,976	1,210
New Jersey	113,840	151,210	105,953	.93	.70	45,257	7,887	–37,370
New Mexico	19,313	19,860	15,166	.79	.76	4,694	4,147	–547
New York	346,725	357,915	306,223	.88	.86	51,692	40,502	–11,190
North Carolina	121,253	111,923	104,761	.86	.94	7,162	16,492	9,330
North Dakota	13,229	12,531	9,766	.74	.78	2,765	3,463	698
Ohio	164,612	151,736	141,782	.86	.93	9,954	22,830	12,876
Oklahoma	55,382	52,438	47,841	.86	.91	4,597	7,541	2,944
Oregon	61,238	60,022	53,566	.87	.89	6,456	7,672	1,216
Pennsylvania	168,479	165,758	137,659	.82	.83	28,099	30,820	2,721
Rhode Island	27,814	22,884	18,594	.67	.81	4,290	9,220	4,930
South Carolina	50,715	49,996	44,739	.88	.89	5,257	5,976	719
South Dakota	11,512	11,458	8,372	.73	.73	3,086	3,140	54
Tennessee	69,796	61,855	54,641	.78	.88	7,214	15,155	7,941
Texas	260,522	252,770	239,755	.92	.95	13,015	20,767	7,752
Utah	26,862	22,080	19,464	.72	.88	2,616	7,398	4,782
Vermont	10,245	8,574	5,788	.56	.68	2,786	4,457	1,671
Virginia	99,742	99,357	81,818	.82	.82	17,539	17,924	385
Washington	89,264	89,411	78,623	.88	.88	10,788	10,641	–147
West Virginia	28,361	24,903	21,652	.76	.87	3,251	6,709	3,458
Wisconsin	106,972	102,442	92,656	.87	.90	9,786	14,316	4,530
Wyoming	7,627	8,092	6,305	.83	.78	1,787	1,322	–465
Outlying areas	51,118	54,559	49,711	.97	.91	4,848	1,407	–3,441
American Samoa	475	408	211	.44	.52	197	264	67
Guam	2,211	1,992	1,711	.77	.86	281	500	219
Puerto Rico	47,338	49,567	46,744	.99	.94	2,823	594	–2,229
Trust Territories	92	576	92	1.00	.16	484	0	–484
Virgin Islands	1,002	2,016	953	.95	.47	1,063	49	–1,014

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[1] New students are those students who are enrolled at the reporting institution for the first time at each of the following levels: undergraduate, graduate, first-professional, or unclassified.

[2] "Students enrolled in State" are all of the new students reported by the institution attended; i.e., all immigrants and "remaining" students (includes foreign students).

[3] "Student residents of State" are all students from a State in which they were residing when first admitted to the reporting institution at the current student level.

[4] "Students remaining in State" are students who attend institutions in their home State.

[5] The immigration exceeds the outmigration by the number of students enrolled from outside the United States.

NOTE.—Data for U.S. Service Schools are included in State totals.

SOURCE: U.S. Department of Education, National Center for Education Statistics, survey of "Residence and Migration of College Students, Fall 1981."

BEST COPY AVAILABLE

[illegible] by Control of Institution and by State, 1972 and 1975

WA
OR
CA
NV
ID
MT
WY
UT
AZ
NM
CO
ND
SD
NE
KS
OK
TX
MN
IA
MO
AR
LA
WI
IL
MI
IN
OH
KY
TN
MS
AL
GA
FL
SC
NC
VA
WV
PA
NY
ME
VT
NH
MA
RI
CT
NJ
DE
MD
DC
AK
HI

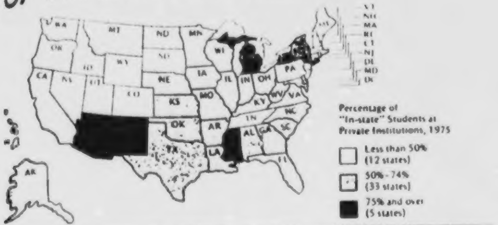
Percentage of "In-state" Students at Public Institutions, 1975

☐ 50%-74% (6 states)

☐ 75% and over (45 states)

Region and State	Percentage of "In-state" Students[a] at: All Institutions 1972	All Institutions 1975	Public Institutions 1972	Public Institutions 1975	Private Instit 1972
50 States & D. C.	84	83	91	88	63
New England	na	na	na	na	na
Connecticut	83	81	94	90	66
Maine	71	73	88	83	29
Massachusetts	68	74	93	93	53
New Hampshire	46	53	66	67	25
Rhode Island	64	70	80	85	45
Vermont	46	51	68	70	19
Mideast	na	na	na	na	na
Delaware	56	72	57	76	45
D. C.	31	28	88	68	18
Maryland	82	81	86	84	65
New Jersey	90	90	96	96	78
New York	89	89	97	97	76
Pennsylvania	82	84	93	94	70
Southeast	na	na	na	na	na
Alabama	87	83	90	86	68
Arkansas	86	83	90	87	66
Florida	85	83	92	89	58
Georgia	81	79	86	84	58
Kentucky	80	82	85	87	57
Louisiana	88	84	93	88	61
Mississippi	90	89	91	90	81
North Carolina	76	81	87	88	51
South Carolina	82	86	89	90	67
Tennessee	76	79	88	89	41
Virginia	79	77	84	79	57
West Virginia	73	77	78	81	47
Great Lakes	na	na	na	na	na
Illinois	89	88	96	93	74
Indiana	76	77	86	85	52
Michigan	90	87	93	89	74
Ohio	84	86	91	92	65
Wisconsin	84				

67 Percentage of "In-state" Students by Control of Institution and by State, 1972 and 1975—*Continued*



Percentage of "In-state" Students at Private Institutions, 1975

☐ Less than 50% (12 states)

▨ 50%-74% (33 states)

■ 75% and over (5 states)

Region and State	Percentage of "In-state" Students[a] at: All Institutions 1972	All Institutions 1975	Public Institutions 1972	Public Institutions 1975	Private Institutions 1972	Private Institutions 1975
Plains	na	na	na	na	na	na
Iowa	75	77	84	85	59	59
Kansas	82	82	86	85	54	58
Minnesota	84	83	90	87	61	65
Missouri	80	82	89	89	57	63
Nebraska	81	80	89	85	52	54
North Dakota	83	81	84	82	69	62
South Dakota	77	75	85	87	54	48
Southwest	na	na	na	na	na	na
Arizona	82	70	84	69	46	79
New Mexico	85	77	86	77	76	77
Oklahoma	87	81	91	83	64	67
Texas	90	88	93	90	75	72
Rocky Mountains	na	na	na	na	na	na
Colorado	70	71	76	74	31	42
Idaho	75	68	85	76	42	37
Montana	83	80	85	82	67	60
Utah	64	66	82	82	37	38
Wyoming	79	71	79	71	—	—
Far West	na	na	na	na	na	na
Alaska	90	94	89	96	93	60
California	94	86	97	88	74	72
Hawaii	86	75	89	78	52	42
Nevada	81	80	82	81	29	16
Oregon	81	79	87	83	45	50
Washington	88	87	91	90	65	68

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[a] Caution is urged in making comparisons between the two years inasmuch as definitions and survey instruments differed.

In 1972, institutions were asked to provide the numbers of students in three categories: in-state, out-of-state, and foreign. "Out-of-state" students were not further categorized by state. "In-state" students were to be those whose "home state" was the one in which the institution that they were attending was located. Each responding institution used its own definition for "home state."

In 1975, institutions provided the numbers of students by specific "home state," i.e., so many students from Alabama, so many from Alaska, etc. "Home state" in the 1975 survey was defined as the state in which the student completed his secondary education.

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2. In the OTA study it is concluded that there is a high degree of correlation between the GNP and the number of engineers employed in the U.S. This conclusion is based on the observation that both GNP and the number of engineers doubled between 1960 and 1982. Is this an adequate basis for establishing such a correlation? Are there other data and studies which confirm this correlation or lead to other conclusions? In your view, how confident can we be that the close relationship between the GNP and the number of engineers employed will remain true in the decades to come?

2. The years 1960 and 1982 were simply picked as convenient end-points to illustrate the larger point that both constant dollar GNP and the number of engineers employed in the work force have grown at about three percent per year for the last three decades. Although exact equality in the two growth rates does not take place every year, the near equality of the average growth rates over reasonably long periods of time is a very robust finding. Whether it will remain true in the future cannot be stated conclusively.

3. What are the major factors that affect the supply of scientists and engineers in a given field and what additional information is needed to better understand the future supply of personnel trained in science and engineering?

3. The major factors that affect the supply of scientists and engineers in a given field are the attractiveness of employment in that field (as measured by salaries and numbers of jobs available); student tastes and preferences; the size of the age-relevant population cohort and the ease of entering and leaving the field in terms of the amount of advanced specialized training required. To understand future supply, accurate projections have to be made of the factors that influence attractiveness of employment, student tastes and preferences, population size and ease of entry. The latter two are fairly well known. The former involve estimates of GNP growth, national R&D spending, defense research and procurement and technological change — all of which are very poorly understood.

4. The projections of future undergraduate enrollments is based on the expectation that the percentage of all those in the 18-21 year old group in any future years, who will go to college, will be 27 percent. Since the number of faculty positions closely ties to the number of undergraduates to be taught, this projection appears to be of high importance. Do you see any reasons why the 27 percent figure will, in future decades, be significantly higher or lower?

4. The 27 percent figure is the projection used in Herring and Sanderson (see reference, Demographics technical memorandum, p. 36). It was probably taken as an average of 28 in 1973 and 26 in 1978. NCES gives figures of 27 percent in 1972, 25 percent in 1977 and 1982, and 26 percent in 1987 and 1992 (Projections of Education Statistics to 1992-93, p. 11). NCES also assumes a range of plus or minus one percent around its intermediate values for 1987 and 1992. There is considerable disagreement over whether the perceived economic value of a college education will increase or decline over the next two decades, a factor that would significantly affect enrollment rates. It is also not clear whether minority enrollment rates will remain the same. In light of all this uncertainty, the assumption of a constant rate of enrollment for the 18-21 year old group, for purposes of general analysis, appears to be the most reasonable one.

5. About 3 percent of the U.S. work force today are scientists and engineers. Is there reason to believe that the technological society of tomorrow will require a higher percentage of personnel trained in science and engineering?

5. According to the most recent data from NSF, scientists and engineers represented 3.7 percent of the employed labor force in the United States in 1984, up from 2.4 percent in 1976. If this upward trend continues, the U.S. will clearly have more and more scientists and engineers as the years go by. Many analysts believe that the increasingly technological nature of U.S. industry will require the services of greater numbers of scientists and engineers in the future. If their analysis is correct, the national requirement for scientists and engineers should increase. Other analysts believe that, rather than an increased proportion of scientists and engineers, a better educated general work force will be essential for the 21st century. It is impossible to prove for certain that the upward trend of the past decade, or the belief of analysts in the need for more scientists and engineers, will in fact hold true in the future.

6. In the OTA report it is stated that a surge in demand for universtiy faculty is likely to occur in the period 2000-2010. Because of the time it takes to train new Ph.D.'s, and because demand for Ph.D.'s will be low in the early and mid-1990's, fewer students are likely to enter and graduate from the Ph.D. pipeline. OTA therefore suggests that it may be necessary to institute "counter-cyclical support programs in the early 1990's" What should the nature of such programs be, in your view?

6. As stated in the OTA statement, p. 8, programs to promote early retirement, and thereby free up funds and positions for new junior faculty in the 1985 to 1995 decade, appear to be non-intrusive, promising counter-cyclical initiatives.

7. In the OTA report it is concluded that there is no strong relationship between graduate enrollment in science and engineering and changes of the graduate school population. What does affect the graduate college enrollment?

7. Graduate student enrollments appear to be most strongly affected by three factors: the level of Federal support for graduate education; state and institutional support for graduate education; and the market for new Ph.D.s and other advanced degree holders. Competition from other career alternatives, such as law, business and medicine, also appears to be a factor.

8. What are the principal factors that influence minorities' decisions to choose a science and engineering career? Could you comment on the potential for an increase in science and engineering careers for women and disadvantaged minorities?

8. According to the OTA survey of information needs related to minorities in science and engineering (Demographics technical memorandum, p. 141), the principal factors that influence minorities' decisions to participate in science and engineering careers are:

- o lack of academic preparedness in elementary and secondary school;
- o lack of role models, mentors and teacher encouragement;
- o lack of parental and peer support;
- o inadequate career and academic counseling
- o lack of confidence and perception of self
- o financial strains; and
- o lack of awareness of career opportunities.

The increase in black and Hispanic participation in science and engineering that took place in the 1970s appears to have leveled off and even, in the case of blacks, declined in the 1980s. Women continue to increase their participation in science and engineering careers but at a decreasing rate. Some analysts believe that these declines are a direct result of the reduction in Federal support for higher education and equality of opportunity that has taken place in the 1980s.

DEMOGRAPHIC TRENDS AND THE SCIENTIFIC AND ENGINEERING WORK FORCE

THURSDAY, FEBRUARY 20, 1986

House of Representatives,
Committee on Science and Technology,
Science Policy Task Force,
Washington, DC.

The task force met, pursuant to notice, at 8:35 a.m., in room 2325, Rayburn House Office Building, Hon. Don Fuqua (chairman of the task force) presiding.

Mr. Fuqua. We begin our second hearing this week as part of the Science Policy Task Force's continuing review of science policy. This morning we'll be discussing demographic trends and the scientific and engineering work force.

And we have Dr. Howard Tuckman, a professor of economics at Memphis State University. He will be our witness, and we'll be glad to hear from you, Dr. Tuckman.

[A biographical sketch of Dr. Tuckman follows:]

Dr. Howard P. Tuckman

Listed in *Who's Who in America* and numerous other *Who's Who* publications, Dr. Howard P. Tuckman is the Distinguished Professor of Economics at Memphis State University where he teaches in the Executive M.B.A. program and directs the Center for Economic Education. An expert in the fields of economic education, human resources, medical economics, public finance, and strategic planning, he has held several national offices in economic associations and currently serves on the editorial boards of several major journals.

Tuckman has been a consultant to such organizations as the Agency for International Development, the American Association of University Professors, the American Council on Education, the Equal Employment Opportunity Commission, the National Academy of Sciences, the National Endowment for the Humanities, the National Institutes for Education, the National Science Foundation, U.N.E.S.C.O, the World Bank, and other national government agencies. In this capacity, he has conducted evaluation studies in Colombia, Nigeria, and Indonesia.

The author of seven books and over sixty five journal articles, Tuckman has been widely acclaimed for his analyses of future economic trends and for his approach to presenting competitive analyses of particular industries to business executives. In addition, his work on high level professional labor markets and on the determinants of salary structures has been cited both in academic journals and employment discrimination cases. He has also published a number of articles on the effects of competition on the markets for medical services.

Tuckman has been a consultant on economic and strategic planning issues to such national and local corporations as: Consad, the Human Resource Policy Corporation, Holiday Corporation and its Holiday Inns division, John Minter and Associates, Leader Federal Savings and Loan Association, the Levi Arthritis Hospital, and Weingartner Hammons. He has spoken in such diverse places as the AAUP Annual Meeting, the Brookings Institution, the Memphis Jobs Conference, the workshops of the National Academy of Science, the Southern Governors Conference, and the Tennessee Defense Attorneys Association. He has also spoken at several universities and is a frequent participant in national meetings.

Tuckman served as Executive Director of the Florida Tax Reform Commission under Governor Graham, as Brookings Economic Policy Fellow to the Office of the Secretary of Health, Education, and Welfare during the Ford administration, and as budget analyst in the U.S. Office of Management and Budget under Presidents Kennedy and Johnson. He has worked in such diverse positions as labor union cashier, stock market clerk, and analyst for the U.S. Wage and Hour Division. Tuckman holds a B.S. degree from the Cornell University School of Industrial and Labor Relations and M.S. and Ph.D. degrees from the University of Wisconsin. Prior to taking his present position in Memphis he served as Director of the Center for the Study of Education and Tax Policy at Florida State University where he was employed for ten years.

Tuckman is currently a member of the Board of Directors of the B'nai Brith Home and Hospital for the Aged in Memphis and a Trustee of the Levi Arthritis Hospital in Hot Springs, Arkansas.

STATEMENT OF DR. HOWARD P. TUCKMAN, PROFESSOR OF ECONOMICS AND DIRECTOR. CENTER FOR ECONOMIC EDUCATION, MEMPHIS STATE UNIVERSITY, MEMPHIS, TN

Dr. TUCKMAN. Thank you, Congressman. I guess I'll best begin with the written presentation.

Mr. FUQUA. Fine.

Dr. TUCKMAN. By your leave, I would also like to indicate that while this written part in front of you deals almost entirely with part-time, I have given your staff an addendum which deals with specific points of the report. And I'll be happy to answer any questions that you would like to ask.

Mr. FUQUA. Fine.

Dr. TUCKMAN. I would like to thank the members of the Science Policy Task Force, and the staff of the Office of Technology Assessment for the opportunity to appear this morning to discuss the OTA technical memorandum, "Demographic Trends and the Scientific and Engineering Work Force."

This memorandum examines the implications of long-term demographic trends and the scientific and engineering work force. It considers barriers to, and future trends that could affect the participation of women and minorities in scientific and engineering careers. I commend sincerely both the House Committee on Science and Technology for proposing this study, and the OTA staff for the way the materials are presented and discussed.

On the whole, this is a well-written and competent summary of the literature. My quibbles with the document are addressed in an addendum to this testimony.

Unfortunately, there is an important national trend which the memorandum fails to address: the growth of the part-time professorate and its implications for scientific and technical policy. My several readings of the document fail to uncover even a single reference to the growth in the number of part-time faculty or its implications for science and engineering policy.

In my view, this is most unfortunate. With the forebearance of the committee, I will try to show why the growing use of part-timers has implications for science policy and why it needs to be incorporated in your deliberations.

Data on part-timers are available from the National Science Foundation, the National Center for Education Statistics, and the Equal Employment Opportunity Commission. Sporadic studies have been conducted by individual researchers, such as John Andes and David Leslie, by institutions such as the American Association of University Professors, academic institutions, and John Minter and Associates.

Because of the difficulty in locating part-timers, the incompleteness of figures at some academic institutions and the discrepancies in definition, these studies do not agree on the size of the part-time population. However, virtually all of the data gathered thus far suggests that the number of part-timers has increased both absolutely and relative to the number of full-timers. Moreover, this increase has been going on since the late 1960's.

For the purposes of this presentation today, I have used part-time and full-time data derived from EEO-6 forms and tabulated by the EEOC Washington office. The data are for the period 1975 to 1981 since this was the period that my colleague, Dr. Karen Pickerill, and I studied in a recent research paper to be published shortly.

I tried to obtain more recent data, but these were not available in time for today's presentation. The data as of today go up through about 1983. The statistics tend to be about 3 years behind.

In our judgment, the EEOC data are more complete, reliable, and consistent than alternative sources for reasons I'll be happy to explain if you wish. Included are all institutions of higher education and all fields.

Now, our tabulations of the EEOC figures are extremely important from the point of view of demographic trends, and I'd like to call just a few of these to your attention.

Part-time positions grew about 32,726 in our period 1975 to 1981. This represented an increase of 16 percent, compared to an 8,438, or 2 percent, increase in full-time positions. So, as you can see, there was quite a difference in the growth rate of the two types of positions.

On the crude assumption that part-timers teach 25 percent of a full-time load, this increase represents the equivalent of 8,182 full-time positions. Or, in other words, in terms of full-time equivalence, as many full-time equivalent positions were created for part-timers as there were full-time positions created for full-timers.

Mr. **Fuqua**. Dr. Tuckman, was that—and I didn't mean to interrupt you—but that is broken down into male or female, or minority or——

Dr. **Tuckman**. Yes, sir.

Mr. **Fuqua**. You'll get into that later on.

Dr. **Tuckman**. In fact, it comes about two down.

Mr. **Fuqua**. Oh, OK.

Dr. **Tuckman**. For every one full-time position added during the 1975 to 1981 period, almost four part-time positions were added, raising the part-time percentage of all positions in academe from 32 to 35 percent.

Here is the answer to your question, Congressman. The number of female part-time positions grew by 24,371 or 35 percent. As a result, females occupied 33 percent of all part-time positions in 1975 and 39 percent in 1981. So the female proportion of the total rose.

In contrast, male part-time employment fell by 6 percent, or 8,391 positions. Now, the growth in the number of female full-time

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positions—and here again, I think this comparison of the growth of female part-time and the growth of female full-time is extremely important—the growth in the number of female full-time positions was significantly slower. Females represented 25 percent of all full-timers in 1975 and only 27 percent in 1981. So there was a 2 percentage point increase in females in the full-time ranks. But as you can see, there was a 6-percent increase in the part-time ranks.

Approximately 87 percent of the part-time positions did not allow their occupants to qualify for tenure. So these were nontenure track positions, almost 90 percent of them. This percentage remained fairly constant over the period of the study. In contrast—and this has been an issue that I know the American Association of University Professors have gotten very interested in recently—the percentage of full-time faculty in nontenure track positions rose by 3 percentage points from 19 to 22 percent.

Now, it should be emphasized that these data include positions at 2-year colleges where the growth in the number of part-time faculty has been particularly strong. However, they're probably likely to show greater part-time growth than figures derived solely from 4-year colleges and universities.

However, I believe that it is important for you to begin with a look at the entire professoriate to understand supply and demand conditions in academe. And that's essentially why we start with this.

When shortages of faculty develop, the 2-year colleges provide a potential pool of labor that the 4-year colleges and universities can tap. Hence, they need to be factored into a model which identifies short-term sources of supply.

Moreover, the large number of part-time positions, and as I indicate to you they represent almost one-quarter of a million people now, the large number of part-time positions suggest that this group has a significant presence on the academic campus. If each part-timer taught only 30 students, a lower figure than is, in fact, the case since my 1976 study showed that an average part-timer taught 1.6 courses, if each part-timer held only one position—and our indication is about 14 percent have another part-time job—all of these—if all of these part-timers were teaching—over 90 percent are—and each student took only one course from each part-timer, over 7.3 million students would be exposed to part-time faculty members. So you're talking about a significant exposure of students to this particular group.

Now, as the part-time professoriate continues to grow, its impact on students will grow even more. And so, it is my own view that it is a mistake for your technical memorandum to completely ignore the existence of this group.

In a recent paper, which will soon be published by the *Educational Record*, Mary Belisle, of the National Academy of Sciences' staff, and I explore the importance of part-time employment for a small but particularly important segment of the professoriate; those with new doctorates.

Using the National Research Council's survey of doctorate recipients, we examined the 1979 job status of those who earned degrees in the 1977 or 1978 period, and the 1983 job status of those who earned degrees in 1981–82. Now, what we're doing, in effect, is we're looking at what happened to these people 1 or 2 years postgraduation. And it's my view that one gets a fairly good indication of labor market conditions of the new entrants into academe by looking at how they have fared 1 or 2 years after their graduation.

Now, several of the results that are reported in that paper really bear on your deliberations, and I'd like to point out two of those. Of the 40,213 new doctorates in our 1977-78 sample, 1,721 or 4 percent,—a very small number compared to what we had talked about before—had part-time status; 5,657 or 14 percent were postdocs, and 30,961 were full time in 1979. The rest were either unemployed or not in the labor force.

In contrast, of the 40,389 new doctorates in the 1981-82 sample, the part-time percentage had grown from 4 to 6 percent. The number had increased to 2,487. And then I give you the statistics here for postdocs and full time. Now, note that the percentage of part-timers is less in the new doctorate population than in academe as a whole. Note, too, that part-time employment is growing absolutely and relative to full-time employment. Moreover, the time period that I'm using in this second tabulation is significantly shorter.

But again, when you ask the question, Congressman, what happened to the women, you find even though these are significantly different pieces of data, they tend to reinforce each other. And what you find is that part-time employment is much more likely among females than males.

In 1979, about 2 percent of the men, but 10 percent of the women had part-time status. In 1983, the equivalent figures were 3 percent and almost 15 percent for females. For both sexes, part-time employment increased between the 2 years an increase of 80 males and 686 females in part-time positions.

Now, Mrs. Belisle and I also explored in a separate analysis the job status of doctorates by field. Using the cohorts and data base described above, we looked at job status in four fields that I thought the committee might find interesting; engineering, math and science; life science; behavioral and social science; and humanities. Humanities is in there more for your comparison than perhaps for your direct interest.

Science and engineering doctorates were less likely to occupy part-time positions than those in the humanities. Less than 1 percent of the doctorates in the EMP field, 2.6 percent of those in the life sciences, and 10 percent in the behaviorial and social sciences had part-time positions in 1983. In contrast, 15 percent of those in the humanities were part time.

Now, again I want to emphasize that lumping that EMP together may be misleading, because in your committtee report, in your section that you deal with the discussion on engineers, fully one-quarter of the people that you cite in your own study, one-quarter of the engineers are occupying part-time positions. So, I think the lumping of the EMP together may be somewhat misleading here.

In behaviorial sciences and the humanities, the growth in part-time positions among new doctorates was about 4 percent. This contrasted with a negligible fall in part-time positions among EMP's, and a growth of slightly more than 1 percent in part-time employment for life sciences.

Now, here again you find the same redundancy with respect to our finding that women are disproportionately represented. New female doctorates were more likely to occupy part-time positions than males. In 1983, 4 percent of the females in EMP, 6 percent in the life sciences, 21 percent in the behaviorial sciences—now, you note that jump in the behaviorial sciences to 21 percent—and 20 percent in the humanities were part-timers. The comparable figures for males were 0.5, 1, 4, and 11 percent. So these new doctorates were disproportionately part time.

In the EMP and LS fields, female employment in part-time status ranked third after full-time and postdoc employment. In the behaviorial science and humanity fields it ranked second, perhaps as a result of the postdocs providing alternative employment opportunities. It's my own hypothesis, if you were to remove those postdocs, the number of people in the engineering, math, physics fields would jump significantly.

Now, what are the implications of these numbers? I thought it would be useful to raise a number of points which the committee might want to ponder. The above analysis suggests that part-time employment is more frequently chosen as a career option by new doctorates in some fields than in others.

In the EMP and life science fields, postdoc appointments may be substitutes for part-time employment. In the behaviorial science fields and the humanities, doctorates holding part-time positions are becoming a significant minority.

If the number of postdocs should be allowed to decline, it seems likely that more doctorates would choose part-time employment as a career option. Likewise, if tenure ratios at 4-year colleges and universities continue to increase, at least some of these institutions might replace full-timers with part-timers. Time permits only a brief summary of all the implications that such an increase might have for national policy.

Implication one: it is extremely likely that faculty who take part-time positions without other employment will lack adequate fringe benefit coverage. My 1979 article with William Bogler in the *Monthly Labor Review*, reported that only 40 percent of all part-timers in our 1976 study had Social Security coverage, 19 percent were covered by retirement plans, 11 percent had workman's compensation, 8 percent had medical insurance, and 6 percent had life insurance coverage. Little has changed since that article was written. Many insurance companies simply refuse to write coverage for part-time employees and, in the absence of national legislation, this is unlikely to change.

Implication two: part-time positions offer no time for paid research. In the absence of public programs designed to offer part-timers the opportunity to engage in research, persons who accept part-time employment as an alternative to full-time employment are likely to be lost to the formal research community. It is possible that some of these persons interested in doing research will deliberately accept part-time employment to be free to pursue their own work. My own suspicion is the number who would fall into that category would be minimal.

Implication three: the part-time labor pool will represent a growing potential source of new faculty supply should shortages develop in the full-time market. My 1984 paper with David Katz in the *Economics of Education Review*, showed that limited price-induced substitution of part-time faculty for full-timers does occur. When the relative price of full-timers becomes more expensive compared to part-timers, we do observe universities substituting part-timers for full-timers.

Similar work with my colleague, Dr. Cyril Chang, which was just published in the last issue of the *Southern Economic Journal*, found similar evidence of price-induced substitution of full-time women for full-time men, and substitution of younger faculty for older faculty, based upon relative price changes.

For the part-time pool to be a meaningful source of new full-time faculty, better selection and hiring procedures need to be implemented. George Biles and I consider how this might be done in detail in our book due out next month called, *Part-Time Faculty: Personnel Management*.

The models built by the OTA staff do not explicitly incorporate the part-time pool as a source of supply. It would be worth exploring whether adding these data would improve the predictability of these models. It would be very worthwhile to this committee to encourage the Federal data-gathering agencies to improve the quality of their data on part-time faculty.

Implication four: we have seen from the above figures that part-time employment is more likely to be a career route for women than for male faculty. In part this is because some women like the flexibility of a part-time position. And in part it's because some simply cannot find full-time work.

My inquiry with Mary Belisle suggests that among new doctorates, about 48 percent of the women in the 1983 survey, and 52 percent of the males were seeking full-time employment. The percentages in 1979 were 51 percent for women and 80 percent for males. This group, which I have previously referred to as the "hopeful full-time" group, often finds barriers to full-time employment.

There is a need, a serious need, to advise those who enter part-time employment of the difficulties they're likely to encounter in converting a part-time position to a full-time one. A need also exists to encourage academic institutions to integrate part-time faculty and to offer them more equal standing with their full-time peers. Biles and I, in the book I mentioned earlier, have some suggestions on how this might be done.

Implication five: it is my belief, not supported by research, that the growth in part-time employment is a byproduct of the fact that the provision of higher education is becoming more costly in the United States. If so, increased budgetary pressures and reduced Federal funding may lead to increased substitution of part-timers at 4-year colleges and universities in the future.

A major increase in full-time salaries would also have this effect. Such substitution would almost inevitably affect the quality of graduating science and engineering students in the future.

I would urge this committee to support a careful study of the use of part-time faculty in science and engineering, with particular attention to the criteria used to select part-timers, the support they receive once they're hired, and how they impact on the quality of instruction. Such a study would provide more detailed information on the impact of the part-time trend than is currently available.

Implication six: the growth of the part-time professoriate could have a very positive impact on the quality of science and engineering training. For many years the medical schools have hired outstanding specialists to lecture part time. These persons bring to the classroom a unique blend of familiarity with the current academic journals and practical experience. Federal policy could encourage the academic community to hire persons of this caliber.

National programs designed to encourage outstanding people to teach part time, tax incentives, or even temporary sabbaticals to outstanding practitioners could lead to a partial solution to the problem of the growing number of foreigners in the classroom. It could also upgrade the quality of existing testimony.

Now, I apologize to the committee, my secretary left off the final page. So if you'll bear with me, I will try to summarize what's on that.

Your report mentions, in some detail, the academic salaries being a factor in the attraction of engineers into the—into academe. One way around the problem of inducing talented people to stay in academe is to not to buy the best brains from industry on a competitive basis, entering into competitive and often costly bidding wars, but rather to bring these brains in on a part-time basis using cooperation between industry and the university as a means of enriching the teaching curriculum.

Two final implications, and implication No. 7, a danger exists that some institutions will hire such a high percentage of part-timers, that colleges lose some of their basic functions. And coming up on the airplane, I happened to be going through the *Chronicle of Higher Education*. I thought it would be interesting for the committee to hear from just an advertisement I picked randomly out of the February 19 *Chronicle*.

Oakland Community College is advertising for a dean for their division of social science and business. In that advertisement they list, "We have 45 full-time faculty and 100 part-timers on our staff": 45 full-time faculty, 100 part-timers. California State University, Chico: 60 full-timers, 30 part-timers. The University of San Francisco: 45 full-timers, 25 part-timers.

Federal policy, to the extent that it can, should discourage the development of institutions overwhelmingly staffed by part-timers. The absence of a cadre of research dollars, of faculty with the time to engage in Government and public service activities, and of normal advising and committee functions can change the nature of the learning experience at college.

Presumably accreditation rules will preclude this from happening. But the pressure to relax these rules increases when shortages of budgetary problems develop. The Federal Government should not control this directly, but it can act through rules governing the distribution of student aid and other funds.

Finally, the last implication is we are experiencing a growth of a new class in the part time, the hopeful full time. Some of my preliminary research has indicated a very, very high correlation between the percentage of people who are seeking full-time employment and who are part-timers, and the conditions of employment within individual fields.

For example, in the biology area, where conditions have tended to be very tight, the percentages of part-timers who are seeking full-time positions are very high. In the engineering fields, where you tend to have a rough balance in the labor market—which I'm sure we'll come to in a little while—we've seen a lower percentage of part-timers. So the part-time variable appears to be a key variable in terms of adjusting the full-time market and siphoning off some of those supply conditions that you dealt with in your report.

In conclusion, I'd like to thank the committee for allowing me the opportunity for me to express my views on the OTA memorandum. As you can see from the above presentation, I feel quite strongly that the absence of a serious discussion of the part-time trend and its implications represents a major shortcoming which needs to be rectified.

I look forward to your comments, criticism, and questions.

[The prepared statement of Dr. Tuckman follows:]

Testimony of Dr. Howard P. Tuckman
Distinguished Professor of Economics
Memphis State University
February 20th 1986

I would like thank the members of the Science Policy Task Force and the staff of the Office of Technology Assessment (OTA) for the opportunity to appear this morning to discuss the OTA Technical Memorandum "Demographic Trends And The Scientific and Engineering Work Force." This Memorandum examines the implications of long-term demographic trends for scientific and engineering personnel policy and it considers both barriers to, and future trends, that could affect the participation of women and minorities in scientific and engineering careers. I commend both the House Committee on Science and Technology for proposing this study and the OTA staff for the way that the materials are presented and discussed. On the whole this is a well written and competent summary of the literature. My quibbles with the document are addressed in an addendum to this testimony.

Unfortunately, there is an important national trend which the Memorandum fails to address; the growth of the part-time professoriate and its implications for scientific and technical policy. My several readings of the document failed to uncover even a single reference to the growth in the number of part-time faculty or its implications for science and engineering policy. In my view this is very unfortunate. With the forebearance of the Committee, I will try to show why the growing use of part-timers has implications for science policy and why it needs to be incorporated in your deliberations.

The Sizeable Growth of Part-Time Faculty Positions in The U.S.

Data on part-timers are available from the National Science Foundation (NSF), The National Center For Education Statistics (NCES), and the Equal Employment Opportunity Commission (EEOC). Sporadic studies have also been conducted by individual researchers such as John Andes and David Leslie, and by institutions such as the American Association of University Professors, academic institutions, and John Minter and Associates. Because of the difficulty in locating part-timers, the incompleteness of figures at some academic institutions, and discrepancies in definition, these studies do not agree on the size of the part-time population. However, virtually all of the data gathered thusfar suggest that the number of part-timers has increased both absolutely and relative to the number of full-timers. Moreover, this increase has been going on since the late sixties.

For the purposes of my presentation, I have used part-time and full-time data derived from EEO-6 forms and tabulated by the EEOC Washington office. The data are for 1975-81 since this was the period that my colleague Dr. Pickerill and I studied in a recent research paper to be published shortly. I tried to obtain more recent data but these were not available in time for today's presentation. In our judgment, the EEOC data are more complete, reliable, and consistent than alternative sources for reasons that I will be happy to explain if you wish. Included are all institutions of higher education and all fields. Tabulation of the EEOC figures reveals that:

> Part-time positions grew by 32,726 (an increase of 16%) compared to a 8,438 (2%) increase in full-time positions. On the crude assumption that part-timers teach 25% of a full-time load, this increase represents the equivalent of 8,182 full-time positions.
>
> For every 1 full-time position added during the 1975-81 period almost 4 part-time positions were added, raising the part-time percentage of total positions from 32% to 35% .
>
> The number of female part-time positions grew by 24,371 (or 35%). As a result, females occupied 33% of all part-time positions in 1975 and 39% in 1981. In contrast, male part-time employment fell by 6% or 8,391 positions during the period.
>
> Growth in the number of female full-time positions was slower. Females represented 25% of all full-timers in 1975 and 27% in 1981. In absolute numbers female positions increased by 11,708 (a 10% increase) compared to a decline of 1% or 3,270 for males.
>
> Approximately 87% of the part-time positions did not allow their occupants to qualify for tenure. This percentage remained fairly constant over the period under study. In contrast, the percentage of full-time faculty in non-tenure track positions rose by about 3 percentage points from 19% to 22%.

It should be emphasized that these data include positions at two year colleges where the growth in the number of part-time faculty has been particularly strong. Hence, they are probably likely to show greater part-time growth than figures derived solely from four year colleges and universities. However, I believe that it is important to begin with a look at the entire professoriate to understand supply and demand conditions in academe. When shortages of faculty develop, the two year colleges provide a potential pool of labor that the four year colleges and universities can tap. Hence, they need to be factored into a model which identifies sources of short term supply. Moreover, the large number of part-time positions (244,552 in 1981) suggests that this group has a significant presence on the academic campus. If each part-timer taught only 30 students (a lower figure than is in fact the case since my 1976 study showed that on average part-timers taught 1.6 courses), each part-timer held only one position (about 14% hold another part-time job), all of these part-timers were teaching (over 90% are), and each student took only one course from each part-timer, over 7.3 million students would be exposed to a part-time faculty member each year. As the part-time professoriate continues to grow, its impact on students will grow even more.

Thus, it is a mistake for the Technical Memorandum to completely ignore the existence of this group.

The Part-Time Positions Held by New Doctorates

In a recent paper soon to be published by the Educational Record, Mary Belisle and I explore the importance of part-time employment for a small but particularly important segment of the professoriate; those with new doctorates. Using the NRC's Survey of Doctorate Recipients, we examine the 1979 job status of those who earned degrees in the 1977-78 period and the 1983 job status of those who earned degrees in 1981-82. Essentially, our inquiry involves the job status of doctorates one or two years post degree. Several of the results reinforce the findings discussed above:

> Of the 40,213 new doctorates in our 1977-78 sample, 1,721 (4%) had part-time status, 5,657 or 14% were postdocs, and 30,961 (77%) were full-time in 1979. The rest were either unemployed or not in the labor force. In contrast, of the 40,389 new doctorates in 1981-82 sample, 2,487 (6%) had part-time status, 6,271 were postdocs (15.5%), and 29,849 were full-time (74%). Note that the percentage of part-timers is less in the new doctorate population than in academe as a whole. Note too that part-time employment is growing absolutely and relative to full-time employment. Moreover, the time period is shorter than the one in the last section.
>
> Part-time employment is more likely among females than males. In 1979, about 2% of the men and 10% of the women had part-time status. In 1983, the equivalent figures were 3% and 14.5%. For both sexes, part-time employment increased between the two years; an increase of 80 males and 686 females in part-time positions.

Mrs. Belisle and I also explored in a separate analysis the job status of doctorates by field. Using the cohorts and data base described above, we looked at job status in four select aggregate fields: 1) Engineering, Math, and Physics (EMP), 2) Life Sciences (LS), 3) Behavioral and Social Sciences (BSS), and 4) Humanities. Our findings suggest that:

> Science and engineering doctorates were less likely to occupy part-time positions than those in the Humanities. Less than 1% of the doctorates in EMP, 2.6% of those in LS and 10% of those in BSS fields held part-time positions in 1983. In contrast, 15% of those in the Humanities were part-time.
>
> In BSS and the Humanities, the growth in part-time positions among new doctorates was about 4%. This contrasted with a neglible fall in part-time positions among EMPs (-0.3%) and a growth of slightly more than 1% in part-time positions for LS doctorates.
>
> New female doctorates were more likely to occupy part-time positions than males. In 1983 4% of the females in EMP, 6% in

LS, 21% in BSS, and 20% in Humanities were part-timers. The comparable figures for males were 0.5%, 1%, 4%, and 11%.

> In the EMP and LS fields, female employment in part-time status ranked third after full-time and postdoc employment. In the BSS and Humanities fields it ranked second after full-time employment.

Implications of These Numbers

The above analysis suggests that part-time employment is more frequently chosen as a career option by new doctorates in some fields than in others. In the EMP and LS fields, postdoc appointments may be substitutes for part-time employment. In the BSS fields and the Humanities doctorates holding part-time positions are becoming a significant minority. If the number of postdocs should be allowed to decline, it seems likely that more doctorates would choose part-time employment as a career option. Likewise, if tenure ratios at four year colleges and universities continue to increase, at least some of these institutions might replace full-timers with part-timers. Time permits only a brief summary of the implications that such an increase might have for national policy.

Implication 1: It is extremely likely that faculty who take part-time positions without other employment will lack adequate fringe benefit coverage. My 1979 article with William Vogler in the Monthly Labor Review reported that only 47% of all part-timers in our 1976 study had Social Security coverage, 19% were covered by retirement plans, 11% had workman's compensation, 8% had medical insurance and 6% had life insurance coverage. Little has changed since that article was written. Many insurance companies simply refuse to write coverage for part-time employees and, in the absence of national legislation, this is unlikely to change.

Implication 2: Part-time positions offer no time for paid research. In the absence of public programs designed to offer part-timers the opportunity to engage in research, persons who accept part-time positions as an alternative to full-time employment are likely to be lost to the formal research community. It is possible that some of the persons interested in doing research deliberately accept part-time employment to be free to pursue their own work.

Implication 3: The part-time labor pool will represent a growing potential source of new faculty supply should shortages develop in the full-time market. My 1984 paper with David Katz in the Economics of Education Review showed that limited price-induced substitution of part-time faculty for full-timers does occur. (Similar work with Dr. Cyril Chang published in the Southern Economic Journal found evidence of price-induced substitution of full-time women for men but in both cases, the effects were not large). For the part-time pool to be a meaningful source of new full-time faculty, better selection and hiring procedures need to be implemented. George Biles and I consider how this might be done in detail in our book due out this March, Part-Time Faculty: Personnel Management. The models built by the OTA staff do not explicitly incorporate the part-time pool as a source of supply. It would be worth exploring whether adding these data would improve the predictability of these models. It would be very worthwhile for this Committee to encourage the federal data gathering agencies to improve the quality of their data on part-time faculty.

Implication 4: We have seen from the above figures that part-time employment is more likely to be a career route for female than for male faculty. In part, this is because some women like the flexibility of a part-time position and, in part, it is because some cannot find full-time work. My inquiry with Mary Belisle suggests that among new doctorates about 48% of the women in the 1983 survey and 52% of the males were seeking full-time employment. The percentages in 1979 were 51% and 80%. This group, which I have previously referred to as the "Hopeful Full-Time" often finds barriers to full-time employment. There is a need to advise those who enter part-time employment of the difficulties they are likely to encounter in converting a part-time position to a full-time one. A need also exists to encourage academic institutions to integrate part-time faculty and to offer them more equal standing with their full-time peers. George Biles and I provide several models in our book for how this might be done.

Implication 5: It is my belief (not supported by research) that the growth in part-time employment is a byproduct of the fact that the provision of higher education is becoming more costly in the U.S. If so, increased budgetary pressures and reduced federal funding may lead to increased substitution of part-timers at the four year colleges and universities in the future. A major increase in full-time salaries would also have this effect. Such substitution would almost inevitably affect the quality of graduating science and engineering students in the future. I would urge this Committee to support a careful study of the use of part-time faculty in science and engineering with particular attention to the criteria used to select part-timers, the support they receive once they are hired, and how they impact on the quality of instruction. Such a study would provide more detailed information on the impact of the part-time trend than is currently available.

Implication 6: The growth of the part-time professoriate could have a very positive impact on the quality of science and engineering training. For many years the medical schools have hired outstanding specialists to lecture part-time. These persons bring to the classroom a unique blend of familiarity with the current academic journals and practical experience. Federal policy could encourage the academic community to hire persons of this caliber. National programs designed to encourage outstanding people to teach part-time, tax incentives, or even temporary "sabbatics" to outstanding practitioners could lead to a partial solution to the problem of the growing number of foreigners in the classroom. It could also upgrade the quality of existing faculty.

The OTA Memorandum notes that the inducement to seek employment outside academe involves not only salaries but also the availability of superior facilities in the private sector. One way around this problem is to buy the best brains from industry on a part-time basis rather than to enter into costly, and often unsuccessful, bidding wars to house them in academe.

Implication 7: A danger exists that some institutions will hire such a high percentage of part-timers that colleges lose some of their basic functions. Federal policy should discourage the development of institutions overwhelmingly staffed by part-timers. The absence of a cadre of research scholars, of faculty with the time to engage in governance and public service activities, and of normal advising and committee functions, can change the nature of the learning experience at a college. Presumably, accreditation rules will preclude this from happening but the pressure to relax these rules increases when shortages or budgetary problems develop. The federal government should not control this directly but it could act through rules governing the distribution of student aid and other funds.

Implication 8: While a significant number of part-timers voluntarily choose this form of employment, some (17% in my 1976 article) are in this job status for lack of a better alternative. Our 1976 work suggested a correlation between a surplus of faculty in a field and the proportion that part-timers represent of total faculty in those fields. More, and better, information is needed on the characteristics and credentials of the Hopeful Full-Time group. Moreover, serious attention needs to be given to finding ways for young scholars who choose this career route to later attain a full-time position.

I would like to thank the Committee for allowing me the opportunity to express my views on the OTA Memorandum. As you can see from the above presentation, I feel strongly that the absence of a serious discussion of the part-time trend and its implications represents a major shortcoming of the report which needs to be rectified. I hope that as you continue your deliberations you will explore further the implications of the growth of the part-time labor force in academe.

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ADDENDUM
More Detailed Commentary on The OTA Memorandum

. The importance of the statement on page 4 needs reinforcing. There are no national labor markets for academics, only markets for faculty trained in individual disciplines. My work on salary determinants showed dramatic differences in the baseline salaries, and in the determinants of both salaries and promotions for the separate fields. Many other researchers have reported similar findings. It is a mistake to treat the academic labor market as a single entity.

.The statement on page 5 that career choice and market forces have a greater impact on supply than demographic forces should be spelled out more carefully. My work with Cyril Chang suggests that while relative salaries affect substitutions among faculty by rank and sex, the price response is small and dominated by other forces. Markets adjust over time, and as Freeman has shown, with a lag. It is important not to overstate the effects of market adjustments and to spell out the mechanisms that do the adjusting.

.On pages 6 and 25 the statement is made that occupational mobility from associated fields is the short-run response to shortage. This is misleading since a variety of sources of supply exist including: 1) Return of Semi-Retired faculty, 2) Reentry of females who dropped out to have children, 3) Entry of persons from industry with degrees in related fields who teach part-time in this field, 4) Entry of students who also teach part-time at other institutions, 5) Entry of persons with a degree in this field who are working in other fields and who either leave these other fields or who teach part-time, 6) Movement of persons teaching at junior college or high school level to four year colleges and universities during shortage periods.

.On page 7 it is important to note that female expectations are shaped by what they can expect to make and how they expect to be treated. In fields where male and female salaries are similar, and where meaningful career ladders for females exist, the economic returns may induce some women to breakout of a sterotyped role.

.On page 40 the statement is made that there is an "extreme" responsiveness of undergraduates to market signals. I would question both what this means and whether it is really true.

.On page 62 the issue is raised of whether university response to declining demand takes the form of reduced tenure rates. Our own preliminary work suggests that two things are happening. First, part-timers are the ones hired on non-tenure tracks. Since the Kuh-Radner model (and others) does not track this group, the trend toward non-tenure track positions is going on but it is not being noted. Second, overall gradual increases in the number of full-time persons in non-tenure track positions are occurring but this does not seem to be affecting the new doctorates. This suggests that those without doctorates are the ones who are being hired into non-tenure track positions. More work is needed on this important question.

.On page 63 there is a need to cite not only the effects of hiring shortages on departments but also the effects of inadequate budgets. The work of John Minter and Associates in Colorado would be helpful in documenting some of the impacts on science and engineering departments.

.On page 64 the Memorandum cites the Carnegie Council on Policy Studies discussion of the effects of aging on university flexibility. There are several important sources of rigidity in academe today including: 1) Overregulation by federal, state, and private entities, 2) Restrictions imposed by union contracts, 3) Limits inherent in the lack of budget growth, 4) Inability to reallocate budgets among growing and shrinking fields, and 5) Limitations created by faculty concern for the future. More information is needed before "aging" can be singled out as the major item restricting university deployment of resources. It is entirely possible that even if tenure ratios were lower, serious problems would still exist.

.On page 65 which discusses the "Further Future" the report should at least mention the possibility that advances in the computerization of academe could alter the traditional faculty-student ratio. The Memorandum totally ignores the computer revolution and the strong possibility that by 1990 much instruction will be done by machine. It would be helpful to at least mention, if not explore, the implications of such a scenario.

.On page 76 the report notes that educational institutions employ only 52% of all PhD scientists and that the variation across fields is substantial. The key point is that faculty go where there are jobs. A serious attempt to "open up" new jobs in academe might involve the offering of mid-career opportunities to faculty in fields where jobs do not exist outside of academe. Work on early retirement shows that a significant minority of faculty are discontent in academe and would seek other employment given the opportunity. Mid-career programs could benefit both individual faculty members and their employers.

.On page 76 Zumeta's study of postdocs is presented. As discussed in my testimony, the postdoc appears to be an alternative to part-time employment. It may also be a court of last resort. In this sense, it assumes a function different from that originally intended. To the extent that it channels off excess supply rather than serves as a training ground for outstanding researchers it raises a question; are there alternative programs that might more effectively channel this highly talented group of people into meaningful permanent positions?

.On page 81 the report indicates that NSF finds 29,000 engineers employed full-time and 8,800 employed part-time. If these figures are correct, part-timers represent 23% of all faculty, reinforcing my earlier point that they are a significant minority today.

.On page 83 I concur with the report that "documented shortages are much lower than shortages determined on the basis of some ideal of quality." As an economist, I am reluctant to base an assessment of labor market conditions on views of what "should be" rather than on what actually exists. What people would like, and what they are willing to pay for, are rarely the same.

.On page 83 the evidence that salaries are higher at public schools and so are vacancies can not really be used to "...call into question the claim that the salary differential is the principal disincentive to a career in academia." There are simply too many other factors at work such as: 1) A larger demand from public institutions, 2) The possibility that public institutions demand more specialized faculty, 3) Differences in the locations of the two types of institutions, etc.

.On pages 83-86 the report hints at, but fails to explicitly state, that one of the problems in evaluating foreign scientists and engineers is the absence of a way of measuring their effect on the quality of the teaching and research effort. A need exists to identify and track this effect.

.On pages 99-103 the report discusses the question of how markets adjust. This is an extremely important area which needs further work. We have surprisingly little information on the adjustment mechanisms unique to specific fields and those which are common to all. The Committee should encourage further work in this area.

.On page 105 the section on impacts should also note the effects on individual morale, on employer demands on employees, and on individual mobility within both the firm and the profession.

Once again, I would like to thank the Committee for inviting me to express my views and I hope that these comments will prove useful in your deliberations.

Howard P. Tuckman
February 20 1986

DISCUSSION

Mr. **Fuqua**. Thank you very much, Dr. Tuckman, for a very well thought-out paper. You mentioned the quality of instruction, and I might add that I'm sure you were excluding Congressman Brown from that since he has performed in a part-time fashion on occasion at colleges and universities for extended periods of informed instruction. But what do you see as the—is the main cause of this increased part-time? You went into the fact that tenure could be one, it could be lack of fringe benefits, that universities have to pay in tight budget times. This is a new innovative way to maybe accomplish the same thing at less cost to the institution. Or is it the fact that people desire less than full-time jobs, when you get more people where you have two bread winners in the same family and maybe they have other pursuits that they wish to do and only teach 1.6 courses or whatever the fraction might come out? Can you elaborate a little further on that? What causes a shift in this direction?

Dr. **Tuckman**. Surely. Well, I think it's operating on both sides of the market, Congressman. It operates on the demand side and on the supply side. Through the American Council on Education I've run a number of workshops for the institutions, academic institutions, over the years. And right here outside of the District, at the University of Maryland, you have one of the largest part-time programs in the country in their evening division.

What seems to be happening is that part-time represents to the institutions, more than anything else, a source of flexibility. This is—you have a situation, which you've commented on in your report, of growing tenure ratios, people quoting figures from 50 to 70 percent—some institutions is even higher. The growing tenure ratios create a problem in the sense that if demand shifts, let's say from English or literature or foreign languages over to the business school, the hands of administrators are pretty heavily tied. If you suddenly have a mass of students who want to take a course in accounting, and you don't know how long that demand is going to last, part-timers are a mighty tempting way of solving your problems and giving you flexibility. If the demand disappears 1 month later or 6 weeks later, you get rid of your part-timers.

So my own feeling, talking to the people on the academic side of the market, the institutions, is that that flexibility is probably far and away from their point of view the most often stated reason. And in reality, there's a second reason, and it's price.

Now, you comment in the report—and I want to really congratulate your staff on emphasizing in that report the adjustment mechanisms inherent in the market. And you're really very much to be congratulated because an awful lot of the so-called manpower projection literature just projects fixed ratios and doesn't pay any attention. And I think it showed the sensitivity of your staff members and OTA that they were able to do this.

The demographers were in control of the field for a long time. And if you ask a demographer what's happening they will—straight line trend. The economists, by nature, we are the keeper of the keys of the church, and our church is the price mechanism. So if you set us down on a topic, we're going to look at that price mechanism and see if we can find it working. And this paper that I mentioned with Chang, what we were asking was: "Does that price mechanism really operate?" And the answer is: "Not as much as you might like." And in that sense, I have a criticism of your report because I think it tends to overstate a bit just how much the price mechanism can do. But there is evidence that part-timers get paid a flat amount, often irrespective of their credentials—maybe Congressman Brown would comment on that one, too—you know, irrespective of their credentials, and their salaries don't rise from one year to another. So if they pay you, for the sake of argument, $1,700 a month or a semester, you may be with an institution 10 years and always get $1,700 a semester.

Over time a gap develops between the part-time salaries and the full-time salaries. The more that gap grows, the more tempting it becomes for an institution to save money by hiring part-timers. So, I think both of those are on the demand side of the market.

Now, on the supply side—you were hinting at and I think you're quite right—there's a very significant component of part-timers who are voluntary. And just to give you the flavor of this, our 1976 study, which was financed by the Ford Foundation, is pretty much the best we've got on this. And it's over a decade later, so I'm not going to attest to what's changed in this respect. But we divided the part-timers into a series of categories. The semi-retired faculty, this was a way of gracefully stepping down. You teach one course, let's say, between 65 and 70. They represented about 3 percent of the sample.

Students—and we had a very particular definition here. If you were teaching in your department we didn't call you part-time. We called——

Mr. **Fuqua**. That would be like a graduate student teaching a basic course?

Dr. **Tuckman**. Yes; well, no. We would call you a graduate student and throw you out of our survey.

Mr. **Fuqua**. Oh, OK.

Dr. **Tuckman**. But if you were a graduate student, let's say for the sake of argument, in English, who was teaching in history, we called you a part-timer. So our criteria was you couldn't be teaching in your own department. Students represented about 21 percent of that total.

The category which we call hopefully full-time—these are people who made it plain that they wanted a full-time job—back then represented about 17 percent of the total. This was the critical group. These were the people who were there because they didn't find anything else.

Now, we had a category called full-mooner. And I guess Congressman Brown would fall into this category. This would be the person who held a full-time job and was doing this on a part-time basis as well. They represented surprisingly only about 28 percent of the total.

And the homeworker, this was the spouse of either sex, male or female, who was staying home either because they had a relative with a disability or they were raising a child or what have you, represented only 6 percent of the total. So——

Mr. **Fuqua**. Well, why would you attribute the reason for the rapid increase in the number of females in this category?

Dr. **Tuckman**. Well, all of the——

Mr. **Fuqua**. Much more than the decline of males.

Dr. **Tuckman**. Well again, if you go back to the OTA memorandum, what shows up very dramatically is that we are experiencing the feminization of academe. And when you look at the doctorates in particular what you'll observe is that the number of males seeking out doctorate degrees has been declining in a large number of fields. So as the percentage of women coming out of academe increases, and as their number grows absolutely, they're going to represent a higher proportion of the population.

We have observed this—we used a different set of figures, the National Center for Education statistics, and looked at the same, essentially the same question. And what we observed was in those numbers, too, you could have a decline in the number of males, you have an increase in the number of women. So I think almost all of the data sets are suggesting that what we're experiencing is women coming out.

Now, the last part of your question, why in the part-time ranks, and I think the answer there is very clear because these women are not finding full-time positions. I know a lot of them are not there because they want to be.

Mr. **Fuqua**. In the study that OTA did, one of the things that they mentioned was the fact that there would be a decline in full-time positions through into the 1990's, but starting in 1995 there would be a demand and an increase. Is that a change from part-time, or do you see part-time continuing to be a major factor?

Dr. **Tuckman**. Well again, I think it's very important for the committee to recognize that the models that were used by OTA, and many of the models that are used now—if I can use a little bit of jargon—are essentially fixed coefficient models. They assume everything else to be equal.

Mr. **Fuqua**. Everything else is constant?

Dr. **Tuckman**. Yes; and, for example, in my addendum, where I give you some detailed comments on the report, I'm very concerned about the fact that the report does not mention the growing trend toward computerization. You know, back in the 1950's everybody was talking about computer assisted instruction and it was too expensive and so it kind of got cast aside. We're dealing with purchasing computer power at lower and lower costs. And my own feeling is that if you're going to project as far out as 1990, you've got to factor in the likelihood that the faculty-student ratios that are now being used are likely to be altered by, you know, increased use of computers. So my own feeling is you may be overstating, you know, the potential demand during that period.

Now, as far as part-time continuing to increase, my own feeling again is as long as part-time salaries continue to become more attractive relative to full-timers because of that growing wedge, I think you're going to see that substitution continue to increase.

I had a dialog about 2 or 3 years back with the Pennsylvania chapter of the AAUP, who were convinced that once the holocaust came that the first people to go would be the part-timers because that was essentially, if you will, the safety factor for institutions.

And they would drop the part-timers and then the full-timers would come back to their old position. That's failed to happen. The institutions have been very reluctant in times of budget retrenchment to let go of the part-timers for the reasons we've discussed earlier.

So I see nothing right now in the cards that would lead to a decline at least in absolute numbers in that population.

Mr. FUQUA. I don't mean to dominate the time. I know my colleagues have a lot of questions. We have, in the course of hearings—not necessarily the science policy, but in particularly in engineering and science, in order to attract more top-flight people into there—we have suggested to universities and so forth that maybe they may get a George Brown or some person who had made a reputation for themselves in industry or research, or something of that type, as a visiting professor either for a semester or maybe one course during the semester, or even in the—I know of several law schools that bring in distinguished lawyers to teach legal ethics or maybe legal writing and stress the importance of it from their perspective; or maybe judges that come in and maybe teach a class.

We, in effect, have encouraged that as a means of attracting people. And I think that is still good that you can bring—or that industry put somebody on a leave of absence for a year and let them go to an engineering school or science—we've been particularly interested in engineering and science—to maybe put some fresh life from a different perspective of somebody that's been out on the firing line rather than someone who's just been in the academic world all of their life.

Do you see that as a harmful thing, or is that——

Dr. TUCKMAN. Well, there are two aspects.

Mr. FUQUA. Well, you referred to not moonlighting, but——

Dr. TUCKMAN. Full mooners?

Mr. FUQUA. Full mooners, yes.

Dr. TUCKMAN. There are two aspects of your question, Congressman. If I can refer to your State, I guess you've seen from my resume that I was at Florida State for a number of years. In a place like Tallahassee, it's kind of difficult to get the kind of talent that you're talking about. You know, in contrast, if you're talking about Florida Atlantic, where baby blue is nearby, I think you have some tremendous opportunities. So a lot of it depends upon where the institution is located.

The difficulty in maintaining some measure of quality is that most institutions today do not have a serious policy toward their part-timers. There's nothing in their faculty handbooks about part-timers, usually the hiring is done at the chairman's level, there's no supervision above the chairman. And so, as a consequence, very often you'll get people who were hired into the classroom, no one in the institution knows what they're teaching in the classroom, no serious review has been done of their credentials. And because it's not monitored, you get a lot of problems as well as a lot of enrichment.

My own feeling is there's a genuine need for the institutions to review their part-time policies and to give these people a little bit more professional stature than they have now by imposing standards and then enforcing them. And that's what it's going to take to give a part-time faculty member some kind of peer status.

Mr. **Fuqua**. Mr. Lujan.

Mr. **Lujan**. Thank you, Mr. Chairman. All of your statistics and all of our discussion has been on the effects on the teaching personnel and on the university. Are there any studies done by interviewing the students and seeing if that's a profitable thing for the student to bring in this outside expert?

One of the things that I see—and not talking about the full-mooners and that sort of thing—is it seems like Congress and politics in general is a veritable garden for harvesting part-timers. Almost everybody that you talk to that is going to retire and you say "Well, what are you going to do?" "Well, I'm going to teach some courses and write a book." Everybody is going to do that. And I see that in universities, retired senators, and that sort of thing, go into.

Are there any studies from the point of view of the student rather than talking about—the institutions?

Dr. **Tuckman**. Yes, sir. There have been several at the community colleges that I'm aware of. They usually will appear in the education journals. The difficulty is that's really just one dimension of the student's experience. When you talk to the students—for example, if Congressman Brown teaches at an institution here in town, and he's exposed to those students, one of the things that will very frequently happen is if he likes a student, he may very well say "Listen, if you're looking for a summer job, come and see me." And there's a lot of that kind of cross fertilization where you'll meet somebody in the classroom and you'll be struck by the fact that this is a particularly talented student. And as a consequence, that student's career path may be altered because you will create an opportunity for that student he might not otherwise have had. So there's that dimension.

And the last dimension is, again, once you get outside the rarified schools—and I say, you know, this committee deals very much with the rarified schools, the top 50 or top 100—a large——

Mr. **Lujan**. The top 10 it seems like.

Dr. **Tuckman**. Well, I guess it all depends on who's sitting here. But one of the things that you'll find is that in a lot of the engineering schools—I'll take, for example, Memphis State as an example—we have an engineering school and we would certainly not rank it in your top 10. But because we have Federal Express in Memphis, and because we have Holiday Inn's Hynet operation, and we have RCA's Sylex, our engineers are getting very, very heavily involved with this uplink-downlink satellite type of communication.

Now, that engineering school, and I think it's typical, if you will, of the great unwashed institutions of the country, tends to be behind business in terms of its training, in terms of its research. You know, we were late in getting PC's into the classroom. The PC's we get in were not up-to-date on the latest hardware. And yet, these institutions are furnishing some of our better companies in the United States with students.

So, if you bring in somebody—to give you an example—from Sylex, who is working with very intelligent modems, and knows the technology of the very intelligent modem, you're enriching those students in ways that you're not going to otherwise enrich them. And these are unmeasurable. I don't know how you really conduct a study unless you pump a lot of money in and do a lot of field interviews.

Mr. LUJAN. You alluded to the figures being lumped together for 2-year institutions and 4-year institutions. Do you have some breakdown—I would imagine that the 2-year institutions are really heavier in the part-time user than 4-year ones. Is that true?

Dr. TUCKMAN. Yes; well, I had called EEOC in the hopes that I might be able to get these data out, and essentially they have budget problems like everybody else and they said: "We'll see you in about 3 months." So if you'll allow me to go back to the 1976 study, which is about as good as I think we're going to get for now, at that time for part-timers as a whole, 2-year institutions represented about 53 percent of the total. So we'd be talking about 47 percent in the other types of institutions. And the 4-year schools, obviously, were about 3-to-1 over the universities in their use of part-timers.

Mr. LUJAN. That's a lot closer than I think it would be. I would think the 2-year institutions would be more in the 60, 70 percent.

Dr. TUCKMAN. But I think you can see here where in terms of what OTA is telling you in that report, OTA is saying two things. Around page 62 or 63, they cite the Kuh-Radner model. And they say the prediction of the research-excellence report was that this tenure ratio would rise. And they say apparently it's not happened.

Well, what's in fact happening is if you don't measure the growth in part-time, and 87 percent of those part-timers are non-tenure track; it is happening but you're just not seeing it happen. So, I think that's very important for you to recognize.

And the other thing is if you do have a quarter of a million people who are part-time, even if you do have that turnaround and the forecast of an increase in demand later on, what you're developing here is a pool. It's a supply pool which can be drawn on in the short term. So were you to indeed experience some kind of critical shortage, my guess is you go back to the 1960's and look at how labor markets adjusted in the 1960's, and you'll see that they drew very heavily on that pool. They'll even go back to the high schools and draw that out of the high schools if they have to. So I think by not recognizing the existence of that pool, you tend to understate the availability of supply in those markets.

Mr. LUJAN. One good way to focus on the cause of the driving factor for part-timers would be the comparison between public institutions and the private. Is there any breakdown in that? I would imagine that the private schools being more limited than the public universities would hire more part-timers.

Dr. TUCKMAN. Let me see if I have that here. That's a—I don't think I brought that particular study with me unfortunately.

Mr. LUJAN. Well, is there data available?

Dr. TUCKMAN. The data are available; yes, sir. Those could be tabulated. I might add that the data are available from the EEOC on minorities. As you know, of all the organizations, you would expect them to have the best data on that. We did not tabulate them, but you can get very detailed information on minorities from them.

Mr. Lujan. Thank you, Mr. Chairman.

Mr. Fuqua. Mr. Brown.

Mr. Brown. Well, let me say I think there's—the insight that you've given is very helpful in filling out a more varied picture than perhaps we tend to assume. Did you—have you, in your research, encountered the situation where jobs are deliberately divided—academic jobs—so that, for example, they will select or allow in some cases two people to fill one full-time job as a way of accommodating to the personal needs of the individuals or something of that sort?

Dr. Tuckman. Yes, sir. I guess when we started the study back in the 1970's, there were all sorts of newspaper stories. The *Wall Street Journal* had had several. They are miniscule. They're less than 5 percent of the group. It sounds very good when you write it down on paper. When you look at it, it does not tend to be a very stable situation for most couples. So very few of those have survived over long periods of time.

Mr. Brown. You mention the fact that the part-time force constitutes a pool or sort of an expandable resource that can be used to move into full-time positions. I found in my own congressional hiring experience that some of these part-time—in my case it turned out to be female faculty members—make extremely good congressional staff members. And it's possible to use that resource as a pool to hire people from out—they're not getting out of academia, but they are moving into another professional arena which they can fill very well. Would that be a general situation where some of these part-time faculty members are also a resource to move into other areas of employment where there are opportunities for them?

Dr. Tuckman. I think so. Again, these motives of these people are extraordinarily mixed. It's one of the things that has kept the professional associations from coming up with a very simple policy, because you recognize that this is a group partially motivated by a desire for voluntary employment, you know, partially a spillover from markets where they couldn't find jobs.

The frustration in dealing with part-time employment is that for most of the people who take it, it's a dead-end position. And there's a phenomenon in academe I suspect many of the committee members have been exposed to. It's a form of groupeeism. And that is if you grow up in Harvard and you've come to love Cambridge, when you graduate from Harvard you don't want to leave the area. And at all the institutions I've ever been exposed to, there is a significant fraction of our population of graduates who don't want to leave the area, whether you're talking about Florida State or the University of Florida or the University of Maryland, or what have you. So they will be the ones that form the core very often of the part-time group. They're hanging in there because they hope somehow or other to get affiliated with their institution. And what will happen over a period of years is burn out.

There was a very angry book written by a professor by the name of Emily Able, which was entitled, *Terminal Degree*. And I think the title tells you something about her feelings about part-time employment. And basically she expresses the feelings of frustration, you know, that a part-timer has because you're led along the garden path. You teach at your institution, you feel like a full-timer, your students come to you, and then one day you realize "I'm going nowhere." So, in that sense they're very good employees because they're so grateful to find a career ladder, you know, that they will take on another job and do very often a lot of what you want them to do.

Mr. **Brown**. Well there is, of course, in any institutional system a tendancy to become overly rigid and to foreclose opportunities for new talent, new opportunities. This happens with Congress as well as universities. And I'm wondering whether we should look at this whole situation as one which has both negatives and positives and seek to accentuate the positives, so as to focus always on the overall goal which is to improve the quality of education and of career opportunities for capable people.

Dr. **Tuckman**. Yes.

Mr. **Brown**. Looked at in that sense, this rise in part-time employment, if it's adequately recognized and obviously we haven't adequately recognized it, can lead to a way of strengthening our overall capabilities to deal with societal problems.

Mr. **Fuqua**. Will the gentleman yield at that point?

Mr. **Brown**. Yes.

Mr. **Fuqua**. Is it also—and academia has been a rather closed society, a closed society on this system that they operated where you became an associate or an assistant professor, you moved up, you went through this. Really nobody else could get in unless you broke into that. Is this a means that this is broken open so that other people can come in? And the way to do it, they're doing it part-time. I think that's along the lines Mr. Brown is talking about.

Dr. **Tuckman**. Given the decline in the number of male positions among new faculty, yes, this is—if you will, the door has been closing on academe, and this is one of the cracks that you can still creep through. I think the problem with that is as the full-time faculty have been recognizing this, there has been more adversarial relationships developing.

You look, for example, at some of the rulings recently in colleges that have been unionized, you find that there's been a great deal of conflict on whether or not to let the part-timers into your full-time bargaining unit or whether they ought to be represented by a separate unit. In some States there has actually been pressure on the legislature to limit, in terms of some fixed ratio or quotas, the number of part-timers. So there is an inherent conflict between the two groups.

Mr. **Brown**. One of the problems that we have recognized in the past has been that there would develop a situation in which there was an inadequate opportunity to do research because of the pressures of teaching. This could be full-time situations in some cases. In the case of the part-time, you've pointed out that there is literally no opportunity to do research if a person is research-oriented.

I'm thinking about the possibility that in order to improve the quality of teaching and the quality of career opportunities that perhaps we ought to look at ways of encouraging private research organizations to consider the possibility of also developing a cadre of part-time employees so that we might have an opportunity to combine a part-time teaching with a part-time researching of different settings. In other words, instead of trying to contract this to minimize this part-time teaching situation, we would look upon it as a positive element providing flexibility in the system, but one which could be made even more desirable if there were part-time research opportunities in other parts of society.

Dr. TUCKMAN. Exactly. Yes, I think this could—my own feeling about the direction that academe is moving now is that it's extremely important for us to encourage relationships between universities and business. That, as you know, is a very difficult thing to do because universities are passionately jealous of their academic freedom. On the other hand, with the resource situation what it is today, there are things that business can offer to a university that the university simply can't get other ways. This kind of interchange of qualified people—and I think that's the key—of qualified people particularly in fields like engineering, could work very successful.

I think you're correct that the medical model is a very effective model to look at. In Memphis we just went through a major attempt to keep St. Jude from moving to St. Louis. As part of a presentation that the Governor and all of the legislators got involved in, there was a great deal of discussion of how do you integrate the St. Jude researchers into the department of pediatrics at UT. There was a great deal of back and forth, as you can imagine, because both were institutions jealous of their perogatives. Part of what came out of that exchange was that there's a great deal of enrichment that these cancer researchers at St. Jude could bring to bear on the UT faculty, and they would teach one course or two courses. What that meant was the school, which is not noted for a heavy research funding, was nonetheless able to offer specialty courses.

Mr. BROWN. Well, I appreciate the thrust of your research and your presentation this morning in this sense, that it does open up a new way of looking at this overall situation in which we look at the problems of achieving quality and equity at the same time we achieve a greater degree of flexibility. I'm afraid that we haven't given that as much weight as it is probably entitled to in the light of the figures that you've presented here.

Thank you.

Mr. FUQUA. Mr. Slaughter.

Mr. SLAUGHTER. No questions.

Mr. FUQUA. Dr. Tuckman, I think you can tell by the questions that your presentation has been very interesting this morning. As Mr. Brown indicated, it opened up some avenues that we certainly will pursue.

Dr. TUCKMAN. Thank you, sir.

Mr. FUQUA. We thank you very much for being here and sharing your comments with us. Thank you.

[Whereupon, at 9:30 a.m., the Science Policy Task Force recessed to reconvene on February 26, 1986.]

[Questions and answers for the record follow:]

QUESTIONS FOR THE RECORD

Responses by
Dr. Howard P. Tuckman

1. **The Science Policy Study in which our Task Force is now engaged is strongly focused on research and graduate education. What role do the part-time faculty play in 1) university and college research, 2) graduate education, and 3) undergraduate education?**

My answer is confined to the science and engineering fields since this is the area of interest to the Committee. It does not deal with the role of part-timers in the medical fields, law, business or education. The evidence suggests that part-time faculty play a limited role in university and college research. In large part, this is because they are usually not hired for this purpose. In part too, they usually do not have the time to devote to these activities or the facilities that would enable them to engage in research. In my testimony before this committee I argued for a program for young part-timers interested in engaging in research. For example, small research grants might be provided to young scholars in science and engineering. This would encourage these persons to make a contribution to their field. It might also help to improve the marginal status of the part-timer.

The data indicate that only a small percentage of part-timers teach at the graduate level. These are often persons in shortage fields like computer programming or electrical engineering. This percentage also includes persons in institutions with limited graduate enrollments. A need exists to introduce top flight engineers and scientists into the classroom on a part-time basis in fields where practical experience augments graduate learning. This is especially true where the equipment or research in industry is more advanced than that at the university. At present, relatively few of these business-university enrichment arrangements exist. Congress should consider various inducements to reward those industries that contribute high quality part-timers in fields where critical skills are needed by institutions of higher education.

The heaviest current use of part-timers is in undergraduate education, particularly in the introductory courses. There is little additional inducement needed to insure an adequate supply of part-time faculty in this area.

2. **Our Task Force has been concerned about the possibility of recreating the tenure crunch in the event extensive hirings of mainly young Ph.D.'s take place in the years after 1995. You suggest that the pool of part-time faculty may, in the future, supply many of the faculty needed in times of high demand. Is this really a major policy option that should be actively pursued as a matter of national policy, and if so, what are the drawbacks and advantages?**

The part-time labor pool provides a viable source of faculty to ease the tenure crunch. At present, about a quarter of a million part-time positions exist. On the conservative assumption that each part-timer occupied four positions (extremely unlikely), this would imply a pool of over sixty thousand faculty. A more likely estimate is that closer to one hundred and fifty thousand persons are currently teaching part-time. A shift to full-time by some of the members of this pool would significantly offset a tenure crunch if it should arise. To ignore part-timers on the grounds that they are not qualified to teach full-time, or because they do not have a research orientation is a mistake. During the shortages of the sixties the colleges drew faculty from many sources including high school teachers, part-time faculty, etc. Should a crunch occur, it is likely that persons teaching part-time will become serious candidates for full-time positions.

The major advantages to utilizing part-timers are: 1) These persons are already teaching in the classroom. They know the system and have proven teaching experience. They can also alleviate shortages without significant time lags. 2) Many part-timers have both academic and business experience. This type of background may be appealing to the type of students currently entering (and likely to enter) higher education in the future. 3) The use of part-timers to ease the transition would be less likely to interfere with normal market adjustments. If full-time faculty are judged to be more desirable, their salaries will rise relative to part-timers. This will induce more graduate students to seek out academic careers and eventually alleviate the shortage. In the interim, part-timers will fill the gap. 4) The proposed countercyclical program would operate with a lag and hence would be sensitive to errors in judgment. Given the state of current forecasting techniques, such a program might aggrevate rather than help the market. In contrast, by their nature, part-time positions can be phased in and out relatively rapidly. 5) The part-time option can be handled by judgments in the private sector. It avoids additional public funding programs to train graduate students.

The major disadvantages of this option are: 1) Part-time faculty often possess fewer credentials than full-timers. This may mean that they are less well informed but the data are insufficient to make a judgment on this. 2) Many part-timers are not oriented toward research. If part-timers were appointed to fill full-time positions it might be necessary to create more research incentives to maintain the research orientation of universities and colleges. 3) The assertion is made that part-timers are not as current in the literature of their field. Appointment of large numbers to full-time positions might lead to a decline in the quality of the knowledge transmitted to students. Adequate data are not available to explore the extent to which this might be a problem. 4) Utilization of existing part-timers, as opposed to creation of new PhDs, would lead to an older labor force which would likely be motivated by different goals. The literature suggests that in some science and engineering fields the best work is done by younger faculty. 5) A decision to rely on existing part-time faculty rather than to train new full-time faculty would reduce the demand for places in the nation's graduate schools. This might lead to some dimunition of revenues at these institutions.

3. It is concluded in the OTA study that there is a high degree of correlation between the GNP and the number of engineers employed in the U.S. This conclusion is based on the observation that both GNP and the number of engineers doubled between 1960 and 1982. Is this an adequate basis for establishing such a correlation? Are there other data and studies which confirm this correlation or lead to other

conclusions? In your view, how confident can we be that the close relationship between the GNP and the number of engineers employed will remain true in the decades to come?

The issue raised by the Committee is an important one. While a conclusion based on the observed fact that both GNP and the number of engineers employed doubled may be aesthetically satisfying, it is not scientifically valid. In the absence of an understanding of the processes underlying the observed association it is not possible to determine how long the relation will persist or what will cause it to alter. I know of no other studies that deal with this issue, although some may exist. In my view, we do not know enough about what causes graduate students to seek out an engineering or science degree, what keeps them in graduate school to get a degree, and what causes them to remain in their degree fields for long periods of time. Under these circumstances, it would be hazardous to forecast that the observed relationship will persist in the future.

4. What are the major factors that will affect the supply of scientists and engineers in a given field and what additional information is needed to better understand the future supply of personnel trained in science and engineering?

The OTA report covers the major known determinants of the supply of scientists and engineers. It also acknowledges that differences exist in the determinants among fields. The last two decades have seen major advances in our ability to model academic labor markets and in our understanding of the limitations of quantitative models. In my view the following additional information is needed: First, improved data to be used specifically as an input into a supply model rather than as a byproduct of statistical data gathering. The improvements should involve data for individual fields related to: high school graduates, newly entering freshmen, undergraduate degrees, graduate entrants, graduate degrees, and new entrants into the labor force. It may seem surprising that such elementary data do not exist but those of us who attempt to model academic labor markets find serious inconsistencies in the available data. These relate to how fields are defined, the way that part and full-time enrollments are defined, etc. Precise data are also lacking on starting salaries and compensation of new degree holders by field and degree level. Moreover, existing data are inadequate in providing an indication of how many faculty remain at the institution from one year to the next, how many change institutions, and how many leave academe. Finally, the data on mobility between academe and the private sector are inadequate to enable serious study of the reasons why faculty leave academe.

Second, better models of what causes differences in behavior among demographic groups are needed. Existing models are too aggregate to enable researchers to answer the last question raised by the Committee. Third, better data are needed on what causes the so-called fixed ratios used in models to change. For example, existing models shed limited light on what determines the percentage of high school graduates continuing on to college. Fourth, no model can adequately predict supply and demand if it fails to accurately capture changes in federal policy. Ways must be found to more accurately predict what federal spending is likely to be and to identify the areas in which it will be focused. Changing public priorities during the seventies caused booms and busts in individual fields. Since the models did not forecast these changes, they did not accurately reflect the conditions that actually occured.

5. The projection of future undergraduate enrollments is based on the expectation that the percentage of all those in the 18-21 year old group in any future years, who will go to college, will be 27 percent. Since the number of faculty positions closely ties to the number of undergraduates to be taught, this projection appears to be of high importance. Do you see any reasons why the 27 percent figure will, in future decades, be significantly higher or lower?

No, I have not looked into this issue enough to be able to evaluate the 27 percent figure or to identify its determinants.

6. About 3 percent of the U.S. work force today are scientists and engineers. Is there reason to believe that the technological society of tomorrow will require a higher percentage of personnel trained in science and engineering?

It is important to recognize that "need" is a relative rather than a fixed concept. Employer demand is not a single number but rather a set of numbers. The number of scientists and engineers demanded will depend on the relative price of these persons, income, national priorities, and related factors. For example, if engineering salaries rise relative to those in other professions, the "need" for engineering personnel will likely diminish, if only slightly, over that prevailing when relative salaries are lower.

A second consideration involves whether the U.S. will continue to export production abroad. If so, this will reduce the demand for scientists and engineers involved in production-based activities. Related is the issue of whether the so-called service economy will grow in the direction of technologically related activities. If the new services demanded require a large technological component, or if we move toward the delivery of new services in areas requiring scientific research, the percentage of "needed" scientists and engineers will increase. It is difficult to make a prediction on the extent to which this is likely to happen in the next few years. However, the potential for major breakthroughs in new drugs, new materials, and artificial intelligence implies an increased technological emphasis in the future.

A third factor that will determine "need" is whether we undertake to engage in competition with other countries in areas that we have thusfar elected to ignore (e.g., camcorders). To the extent that the U.S. undertakes a technological race, as in the case of our space program, demand for scientific and engineering personnel will be increased. It should be noted that whether we engage in such a race will more likely be determined by political factors than by economic models.

7. It is suggested in the OTA report that a surge in demand for university faculty is likely to occur in the period 2000-2010. Because of the time it takes to train new Ph.D.'s and because demand for the Ph.D.'s will be low in the early and mid-1990's, fewer students are likely to enter and graduate from the Ph.D. pipeline. OTA therefore suggests that it may be necessary to institute "counter-cycle support programs in the early 1990's." What should the nature of such programs be, in your view?

In my view the Committee needs to undertake several careful research studies before recommending or implementing a "counter-cycle" support program. First, further research is needed to explore the effect that existing post-doc programs have had on the supply of new faculty. These programs provide insights into the likely effect that a new program would have on the labor market. Second, research is needed to identify the several lags associated with introduction of the proposed programs; implementation in the field, awareness by students that it exists, and response in the form of new enrollments. In the absence of data on these lags, it is difficult to determine whether a congressionally supported inducement program would have the desired effect or whether it could be timed to be truly counter-cyclical. Third, the Committee should also fund research to determine why the number of new doctorates has leveled off and to identify those fields in which market response is insufficient to enable adjustments to occur unaided.

If the Committee agrees with the above research agenda, and if their research suggests that a counter-cyclical program (or programs) is warranted then a number of key issues need to be addressed: 1) What should be the criteria to determine when such a program should be implemented for a given field? 2) What criteria should be used to determine which fields have priority? 3) Under what circumstances should such a program be commenced and terminated? 4) Who should fund such programs and how should they be administered?

I personally am not convinced that the projected surplus will arise. Moreover, if the proposed scenario should materialize in the 1990s, the ensuing publicity may be sufficient to induce new graduates to consider an academic career. Before the Committee implements a program it should first seek evidence that markets do not adequately adjust to projected shortages. Such evidence is not convincingly offered in the OTA report.

8. In the OTA report it is concluded that there is no strong relationship between graduate enrollment in science and engineering and changes of the graduate school population. What does affect the graduate college enrollment?

Graduate college enrollment is affected by many random factors, tastes and preferences, and by what economists refer to as opportunity costs. In particular, the availability of high paying jobs outside of academe, the presence or absence of the draft, and perceptions regarding the desirability of particular jobs all seem to influence enrollments. Better data are needed on the causes of mobility between the academic and business sector. Better information is also needed on the responsiveness of graduate enrollments to starting salaries in M.A. and PhD level jobs. Finally, we need to know more about the factors which cause BA holders to return to graduate school to acquire an advanced degree.

9. Could you identify the principal factors that influence minorities' decisions to choose a science and engineering career and comment on the potential for an increase in science and engineering careers for women and disadvantaged minorities?

Because this line of inquiry lies outside my area of expertise, I prefer not to comment on it. My colleague, Cyril Chang, and I are currently working on a paper on the number of minority group members who are part-time.
April 10 1986

DEMOGRAPHIC TRENDS AND THE SCIENTIFIC AND ENGINEERING WORK FORCE

THURSDAY, FEBRUARY 27, 1986

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND TECHNOLOGY,
SCIENCE POLICY TASK FORCE,
Washington, DC.

The task force met, pursuant to call, at 8:35 a.m., in room 2325, Rayburn House Office Building, Hon. Don Fuqua (chairman of the task force) presiding.

Mr. **FUQUA**. Good morning.

Dr. **HANSEN**. Good morning.

Mr. **FUQUA**. This is our third and final day of hearings of demographics and manpower by our Science Policy Task Force.

On the first day we heard from Dr. Gene Frankel of the Office of Technology Assessment, and he summarized the OTA's comprehensive study on "Demographic Trends and the Scientific and Engineering Work Force," which is an excellent study of the supply of scientists and engineers.

On the second day we heard from Dr. Howard Tuckman of the Memphis State University, and he gave us additional insight into the role of part-time faculty at our universities for the training of scientists and engineers.

Today we have the honor of having with us Dr. W. Lee Hansen, who is a professor of economics and the director of the Industrial Relations Research Institute at the University of Wisconsin at Madison.

Professor Hansen, we welcome you to our hearings and are pleased to hear from you at this time.

[A biographical sketch of Dr. Hansen follows:]

DR. W. LEE HANSEN

W. Lee Hanson is Professor of Economics and of Educational Policy Studies at the University of Wisconsin—Madison. He also is Director of the Industrial Relations Research Institute. He holds a Ph.D. from the Johns Hopkins University, has taught at Johns Hopkins, UCLA, and Wisconsin, and has been a Research Fellow at the Brookings Institution, a Postdoctoral Fellow at the Univeresity of Chicago, and a Guggenheim Fellow.

Hansen serves as a member of the Committee on National Needs for Biomedical and Behavioral Research Personnel of the National Academy of Sciences-National Research Council, chairs the Committee on the Economic Status of the Profession of the American Association of University Professors, heads the Committee on Economic Education of the American Economic Association, and recently completed a term as Editor of the *Journal of Human Resources*.

Hansen's recent research has concentrated on how labor markets for scientists and engineers respond to changes in demand, the impact of occupational projections, academic labor markets, and how student financial aid affects postsecondary education attendance patterns.

Of particular relevance to his testimony are serveral recent publications: "Is There a Shortage of Engineers? A review of Four Studies," in *Labor Market Conditions for Engineers: Is There a Shortage?* National Academy Press, 1984 "Faculty Demography: Supply and Demand," in Darrell Lewis and Shirley Clark (eds.), *Faculty Development and Vitality*, Columbia University Press, 1985. "Faculty Retirement and the Effect on Demand," in *Forecasting Demand for University Scientists and Engineers: Proceedings of a Workshop:* National Academy Press, 1985.

STATEMENT OF DR. W. LEE HANSEN, PROFESSOR OF ECONOMICS AND OF EDUCATIONAL POLICY STUDIES, AND DIRECTOR OF INDUSTRIAL RELATIONS RESEARCH INSTITUTE, UNIVERSITY OF WISCONSIN—MADISON, WI

Dr. HANSEN. Thank you very much.

I have some prepared comments which I will proceed to go through and amplify on a few points that are not spelled out as fully as I wished. Anyway, I am very pleased to be here, and I take as my point of departure the December Technical Memorandum prepared by OTA, "Demographic Trends and the Scientific and Engineering Work Force."As I note, I was an advisory committee member of the advisory committee on this report and had some input to it, but never as much as if I were the author of it.

Scientists and engineers are key occupational groups in advancing the Nation's economic growth, enhancing the Nation's security and improving the competitiveness of the American economy. Over the past 40 years there has been a lot of concern about the adequacy of the supply of scientists and engineers, and this is heightened periodically by the force of external events and also by explicit national policy decisions.

We have numerous examples where demand has suddenly increased, reflected by the acceleration of demand accompanying the Korean war, the space effort in the late 1950's and early 1960's, the Vietnam buildup in the late 1960's, the search for alternative energy sources following the energy crisis of the mid-1970's, the explosion of activity in the biotechnology field beginning about 1980 and, most recently, the rapidly developing SDI program in the Department of Defense.

In each of these cases, demand expanded rapidly, forcing employers to scramble for the limited existing supply of science and engineering talent. As time passed, newly trained people entered these fields while at the same time members of the experienced labor force were pulled in from other fields that required related types of training. The adjustments were never easy but the remarkable flexibility and adaptability of our labor markets brought about relatively rapid adjustments.

As we look ahead toward the 1990's and beyond, we confront a new phenomenon, namely, potential limitations on the supply of newly trained engineers and scientists.

Here I depart a bit from what I wrote down earlier. Several new developments account for this concern. One is the result of smaller birth cohorts of the 1970's that will reduce the size of the traditional college age group and presumably reduce enrollments, first at the undergraduate level and then later on at the graduate level.

Second, we have the reduced size of faculties which will be a result of the declining enrollments in the coming decade or more, and this means we will have a smaller stock of Ph.D.'s available to help train new people.

And, third, we will have the beginning of extensive retirements of faculty who entered the profession in their early 1960's that helped to accommodate the rapid increase in enrollments of that time.

So this combination of forces suggests that the relatively smooth and rapid adjustments that we have had in the past can no longer be counted on to deal with increases in future demand. Not only will the flow of new entrants be smaller, but the stock of available people to help train them will be considerably diminished.

What has not been clear in these discussions is how much pressure these labor markets will experience in the future. Industry's demand is likely to continue expanding. Additional personnel will be required to maintain, if not expand, our R&D efforts. And, finally, there will be a resurgence of demand for scientists and engineers in the Nation's colleges and universities when enrollments begin to rise in the 1990's.

So what I would like to do is comment on the report which, as you well know, has several major portions: The first dealing with the flow of undergraduates; the second explores the impact of these flows on graduate education and the academic labor market; then there is a long discussion of the industrial labor market; and the final section examines what might be done to make S&E's, science and engineering careers more attractive to women and minorities who traditionally have not entered these fields.

What is interesting about this report is it takes a look not only at the short term but the longer term, up to the year 2010. I would give this report high marks for its completeness and the care with which it has been done. Its conclusion that demographic trends will not be decisive in affecting either the numbers of S&E personnel or their capacity to perform seems quite reasonable. This perhaps surprising finding stems from evidence showing that both students and educational institutions are quite flexible in adapting to new conditions, employers are skillful in adjusting their demand for new personnel and, above all, these labor markets respond quickly in accommodating to prospective imbalances between supply and demand.

Now, as you know, the major focus of the report is on the flow of new entrants into S&E fields. While it is certainly true that the size of the typical college age cohorts, age 18 to 24, will decline through the early 1990's, this does not necessarily mean a decline in the number of new S&E entrants into the labor force. As the report points out, the increased enrollment of older students is likely to fill some of the gap. In addition, small changes in the proportions of the students choosing to train in S&E fields and/or in the proportions of graduates who choose to enter S&E employment fields could turn what might appear to be unduly limited supplies of new entrants into considerably larger numbers that would preclude labor market shortages.

Now, what we are unclear about in all of this is the magnitude of these possible responses. Past evidence suggests that these labor markets have been quite flexible. Projecting ahead is much more problematic. In particular, while the enrollment of older students is likely to increase or at least hold steady, we are not really sure how many of them will prepare for S&E fields and, in particular, many of the older students are women who are typically less inclined to prepare for engineering and scientific careers. So we simply don't know what the impact of these older students will be.

What will it take to bring about shifts in the enrollment patterns of undergraduates toward S&E training or changes in the choice of employment fields toward S&E careers? We may believe these adjustments are possible and even probable, but we have relatively little evidence to offer in support of such beliefs. So the fact that there will be these other things going on or could occur, we are a little unsure about the magnitude of their effects and whether they will really preclude the shortages of the kind which are discussed.

Now, the focus, as I mentioned here, is really on the new entrants; but we also have a pool of already experienced S&E personnel who are out there, and if the behavior—if the labor markets for newly trained entrants are unduly tight, we can probably expect the already experienced group to react in some way. Some may be induced to leave their current jobs and to transfer to high-demand fields. Others may be persuaded to delay retirement and thereby help meet pressing needs for their services. Still others may undertake additional training to enhance their knowledge and skills and thereby permit them to move into these high-demand fields. The possibilities of these adjustments are really quite substantial, and the pool of individuals who could adjust is very large.

I guess if I had to identify one weakness of the report, it is really a failure to give more attention to these possibilities, certainly in the discussion of the academic labor market.

Now, assuring an adequate supply of new faculty members is really more difficult, and here I get to some of the key points and I am less sanguine about how easily we can expect smooth adjustments in this sector over the next decade or more.

The need for faculty in S&E fields will decline in the coming decade because of the demographic trends already mentioned. If some of the adjustments discussed above occur, this could offset, partly or fully, the declines induced by demographic forces. In the meantime and faced with considerable uncertainty, institutions of higher education are going to behave quite conservatively. This means they are likely to gear their hiring of faculty to the typical college age group from which the bulk of potential S&E personnel have always come. Thus demand for new faculty will be weak unless it becomes much clearer enrollments are on the upward move once again.

Now, the supply of potential faculty members in the S&E fields is also likely to be constrained for various reasons. First, future opportunities look quite bleak for new Ph.D.'s in light of demographic forces. The decline in the number of 18-year-olds and the likelihood that larger proportions of experienced faculty members will continue working beyond the age of mandatory retirement which, as you know, has been raised from 65 to 70 a few years ago and in some cases eliminated altogether, as in my own State of Wisconsin, a decision which I am not at all happy about.

Second, the decline in new labor force entrants is going to intensify competition for high school graduates. The combined demand by industry, educational institutions for students, and the military, will very likely push up earnings and perhaps deter some high school graduates from going on to college. The same process will repeat itself several years later for college graduates. The reduced flow of new graduates will push up salaries for new job seekers and thus deter people from going to graduate school. Essentially this process will repeat itself at the Ph.D. level but by then considerable damage will have been done.

Third, the financial pressures faced by colleges and universities in the interim are likely to be quite severe. This may well require them to accelerate the rate of increase in student charges for tuition, reduce resources available for research and teaching assistants at the graduate level, and hold down faculty salary increases.

Let me interpolate a fourth point, 3(a). Related to this is the deterioration in the real salaries of the faculty members that has been going on since the early 1970's. Salaries are down roughly 15 percent in real terms over that period, and they are down by about 15 percent relative to the private sector. So the financial inducements out there for people to get Ph.D.'s in these fields are considerably diminished.

Fifth, or fourth as it states here, increasingly large proportions of Ph.D. recipients are likely to be foreign nationals who will face pressure to return to their home countries rather than remain here. This will further depress the supply of Ph.D.'s available in U.S. labor markets.

In short, the market for Ph.D. engineers, in particular, is likely to be extremely tight, thus making it difficult to recruit adequate numbers of new faculty members to train the next generation of engineers. I think the situation will be much less serious for scientists, largely because their opportunities in the private sector are so much more limited than for engineers.

I was asked to comment on the use of training grants to stimulate the supply of new S&E personnel. As you know, training grants have been used for some years to aid in the development of new research personnel, particularly in the biomedical and behavioral sciences. This system has worked reasonably well, being predicated on the notion the research training produces new knowledge that is unlikely to be financed by other than public funds.

Extending the training grant to engineering raises a variety of issues. Engineering Ph.D.'s who are most likely to engage in R&D activity are much more likely than scientists to go into the private sector. There is simply a big demand for them, but because they do go into the private sector where the research results are generally less accessible than if they were in the public sector, the justification for research training support from public funds is considerably weaker. At the same time, there is a clear need to augment the number of Ph.D. engineers. Several private foundations and firms have recently offered support for graduate training in engeering, and I think it's hoped by many observers that others will emulate these actions. This is clearly a move in the right direction, but it is unlikely to be sufficient.

Some additional stimulus will be required. But even if it is felt that training grants might be useful in the short run, nobody has yet discovered a mechanism for turning on and off the flow of training grants as labor market conditions change. And so if you are thinking along these lines, I would advocate caution. It's not quite apparent that training grants can be a useful and flexible mechanism for dealing with Ph.D. manpower problems in engineering and similar fields.

Finally, I was asked to comment on the report's recommendations on women and minorities, and I sum up my wisdom on this. It is obvious that opening up opportunities for these groups could help to alleviate future supply bottlenecks. I would not be too optimistic, however, about the magnitude of responses to whatever actions are taken. It is certainly true that female high school graduates are on average much better prepared for college than are minorities, and in this case I talk about blacks who would be the major group. It's also possible to visualize more females educating themselves for careers in the S&E fields, but for lots of reasons we probably don't understand they display considerably less interest in doing it than do males. I am not sure we understand the reasons for these preferences, but in any case I see little prospect that females will fill much of the gap, particularly in engineering.

For blacks, the prospects are not highly favorable either. Not only do blacks come to college considerably less prepared than whites, but those who graduate are faced with an abundance of job opportunities that offer easier paths of advancement than additional years of graduate study required in so many S&E fields.

So I would certainly support efforts to attract more women and minorities into S&E fields. At the same time, unless these efforts are enormously successful, I do not foresee these groups providing any important margin of difference in dealing with S&E labor market problems between now and the mid 1990's.

So I conclude by commending OTA for its excellent report in trying to help us sort out these issues. Many uncertainties remain, but we are much better informed as a consequence of this report.

[The prepared statement of Dr. Hansen follows:]

The Impact of Demographic Trends on the Scientific and Engineering Work Force

Testimony by

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Before the

Science Policy Task Force
Committee on Science and Technology
U.S. House of Representatives

February 27, 1986 (rev.)

Mr. Chairman: It is a great privilege for me to speak before the Science Policy Task Force this morning on a topic of utmost importance, namely the impact of demographic trends on the scientific and engineering work force. I take as my point of departure the December 1985 Technical Memorandum Demographic Trends and the Scientific and Engineering Work Force. The report was prepared by the Office of Technology Assessment at the request of the Science Policy Task Force. I served as a member of the Advisory Group during the preparation of this report.

Scientists and engineers are regarded as key occupational groups in advancing the nation's economic growth, enhancing the nation's security, and improving the competitiveness of the American economy. Over the past forty years there has been continuing concern about the adequacy of the supply of scientists and engineers. Such concerns have been heightened periodically because of external forces as well as explicit national policy decisions. We have numerous examples, including the acceleration of demand accompanying the Korean War, the space effort in the late 1950s and early 1960s, the Vietnam military buildup in the late 1960s, the search for alternative energy sources following the energy crisis of the mid-1970s, the explosion of activity in the biotechnology field beginning around 1980s, and most recently, the rapidly developing SDI program in the Department of Defense.

In each of these cases demand expanded rapidly, forcing employers to scramble for the limited existing supply of science and engineering talent. As time passed newly trained people entered these fields while at the same time members of the experienced labor force were pulled in from other fields which required related types of training. The adjustments were never easy but the remarkable flexibility and adaptability of our labor markets brought about relatively rapid adjustments.

As we look ahead toward the 1990s and beyond, we confront a new phenomenon, namely, potential limitations on the supply of newly trained engineers and scientists. Several new developments account for this concern. One is the result of the smaller birth cohorts of the early 1970s which will reduce the size of the traditional college age group and presumably reduce enrollments, first at the undergraduate level and later at the graduate level. This will be accompanied by a reduction in faculty size, reflecting long-standing views about appropriate student-faculty ratios. This will reduce the capacity of the system to respond to increases in the demand for scientists and engineers. In addition, we face the prospects in the mid-1990s of substantial retirements of faculty members who were hired to teach the first waves of the baby boom population that entered the labor force in the 1960s. This combination of forces suggests that the relatively smooth and rapid adjustments of the past can no longer be counted upon to deal with increases in future demand.

What has not been clear in these discussions is how much pressure these labor markets will experience in the future. Industry's demand is likely to continue expanding. Additional personnel will be required to maintain if not expand our research and development efforts. And finally, there will be a resurgence of demand for scientists and engineers in the nation's colleges and universities when enrollments begin to rise again in the 1990s.

Thus, my purpose is to assess the effectiveness of the OTA report in elucidating these issues, evaluate the report's conclusions, and indicate what additional lines of research need to be pursued.

* * * * *

The OTA report has several major parts. The first focuses on the flow of students through undergraduate degree programs that set the stage for entering the scientific-engineering (S/E) fields or undertaking additional training prepatory to entering these fields. The second explores the impact of these flows on graduate education and the academic labor market. The third looks at the industrial market. The final section examines what might be done to make S/E careers more attractive to women and minorities who traditionally have not entered S/E fields. Throughout, attention is given not only to the near-term situation but also the long-run outlook to the year 2010.

I would give this report high marks for its completeness and the care with which it has been done. Its conclusion that demographic trends will not be decisive in affecting either the numbers of S/E personnel or their capacity to perform seems quite reasonable. This perhaps surprising finding stems from evidence showing that both students and educational institutions are quite flexible in adapting to new conditions, employers are skillful in adjusting their demand for new personnel, and above all, these labor markets respond quickly in accommodating to prospective imbalances between supply and demand.

The major focus of the report is on new entrants into the S/E fields. While it is true that the size of the typical college-age cohorts (age 18-24) will decline through the early 1990s, this does not necessarily mean a decline in the number of new S/E entrants to the labor force. The increased enrollment of older students is likely to fill some of the gap. In addition, small changes in the proportions of students choosing to train in S/E fields and in the proportions of graduates who choose to enter S/E employment fields could turn what might appear to be unduly limited supplies of new entrants into considerably larger numbers that would preclude labor market shortages of scientists and engineers.

What we remain uncertain about is the magnitude of these several possible adjustments. Past evidence would suggest that these labor markets have sufficient flexibility to respond. Projecting ahead is much more problematic.

For example, while older students are a rising proportion of all undergraduates, how many of them are preparing for entry into S/E employment fields? We simply do not know. What will it take to bring about shifts in the enrollment patterns of undergraduates toward S/E training and changes in the choice of employment fields toward S/E careers? We may believe that these adjustments are possible and even probable. But we have relatively little evidence to offer in support of such beliefs.

Even if these responses are less strong than suggested, still other adjustments can occur. Of particular importance is the behavior of the pool of already experienced S/E personnel. If the labor markets for newly trained entrants are extremely tight in particular fields, S/E personnel in the experienced pool are unlikely to remain impassive. Some of them may be induced to leave their current jobs and to transfer into high demand fields. Others may be persuaded to delay their retirements and thereby help to meet the pressing needs for their services. Still others may decide to undertake, additional training or retraining that will enhance their knowledge and skills, thereby moving them from marginal to the expanding sectors of the market. The possibilities for adjustment are substantial, and the pool of individuals who might adjust is very substantial. I had to identify one weakness of the report, it is the failure to give more attention to these possibilities.

Assuring an adequate supply of new faculty members is more difficult, and I am less sanguine about how easily we can expect smooth adjustments in this sector over the next decade or more. The need for faculty members in the S/E fields will no doubt decline in the coming decade because the demographic trends seem so apparent. If some of the adjustments discussed above occur, they could offset, partly or fully, the declines induced by demographic forces. In the meantime and faced with considerable uncertainty, institutions of higher education are going to have to behave conservatively. This means that they are likely to gear their hiring of faculty to the typical college-age group from which the bulk of potential S/E personnel has always come. Thus, demand will be weak until it becomes much clearer that enrollments are on the upward move once again.

The supply of potential faculty members in the S/E fields is also likely to be constrained and for various reasons.

oo First, future opportunities look rather bleak for new PhDs in light of demographic trends--the decline in the number of 18-year olds and the likelihood that larger proportions of experienced faculty members will continue working because the age of mandatory retirement has been raised (from 65 to 70) and in some cases eliminated altogether (as in Wisconsin).

oo Second, the decline in new labor force entrants is going to intensify competition for high school graduates. The combined demand by industry, educational institutions, and the military will very likely push up earnings and perhaps deter some high school graduates from going on to college. The same process will repeat itself several years later for college graduates. The reduced flow of new graduates will push up salaries for new job seekers and thus deter people from going on to graduate school. Eventually, this process will repeat itself at the PhD level but by then considerable damage may have been done.

oo Third, the financial pressures faced by colleges and universities in the interim are likely to be severe. This may well require them to accelerate the rate of increase in student charges for tuition.

reduce resources available for research and teaching assistants at the graduate level, and hold down faculty salary increases.

oo Fourth, related to this is the deterioration in real faculty salaries that has already discouraged the entrance of many promising young people in to graduate programs and into academic teaching and research positions.

oo Fifth, increasingly large proportions of PhD recipients are likely to be foreign nationals who will face pressure to return to their home countries rather than remain here; this will further depress the supply of PhDs available in U.S. labor markets.

In short, the market for PhDs engineers, in particular, is likely to be extremely tight, thus making it difficult to recruit adequate numbers of new faculty members to train the next generations of engineers. I think the situation will be much less serious for scientists, largely because their opportunities in the private sector are so much more limited than for engineers.

Your invitation asked me to comment on the use of training grants to stimulate the supply of new S/E personnel. As you no doubt know, training grants have been used for some years to aid in the development of new research personnel in the biomedical and behavioral sciences. This system has worked reasonably well, being predicated on the notion that research training produces new knowledge that is unlikely to be financed by other than public funds. Extending the training grant system to engineering raises a variety of issues.

Engineering PhDs,those who are most likely to engage in productivity, are much more likely than scientists to go into the private sector. But because they do go into the private sector where their research results are less generally accessible than if they were in the public sector, the justification for research training support from public funds is much weaker. At the same time there is a clear need to augment the number of PhD engineers. Several private foundations and firms have recently offered support for graduate training in engineering, and it is hoped by many observers that others will emulate these actions. This is certainly a move in the right direction but it is unlikely to be sufficient. Some additional stimulus will be needed.

Even if it is felt that training grants might be useful in the short run, to stimulate the production of more S/E personnel nobody has yet discovered a mechanism for turning on and off the flow of training grants as market conditions change. Hence, I would advocate caution because it is not yet apparent that training grants can be a useful and flexible mechanism for dealing with the PhD manpower problems in engineering and other similar fields.

Finally, I want to comment on the report's recommendations on women and minorities. It is obvious that opening up opportunities for these groups could help alleviate future supply bottlenecks. I would not be too optimistic, however, about the magnitude of responses to whatever actions are taken. It is certainly true that female high school graduates are on average much better prepared for college than are blacks, for example. While it is possible to visualize more females educating themselves for careers in S/E, they display considerably less interest than do males in pursuing such careers. I am not sure we understand the reasons for these preferences. In any case, I see little prospect that females will fill much of the gap, particularly in engineering. For blacks, the prospects are not highly favorable either. Not only do blacks come to college considerably less well prepared than whites, but those who graduate are faced with an abundance of job opportunities that offer easier paths of advancement than additional years of graduate study required in so many S/E fields.

I certainly support efforts to attract more women and minorities into S/E fields. At the same time, unless these efforts are enormously successful, I do not foresee these groups providing any important margin of difference in dealing with S/E labor market problems between now and the mid 1990s.

I wish to conclude by commending the Office of Technology Assessment for its excellent work in trying to sort out the issues. Many uncertainties remain but we are much better informed as a consequence of this report.

DISCUSSION

Mr. **Fuqua**. Thank you very much, Dr. Hansen.

The number of foreign nationals that, as you mentioned, has increased over the last 10, 15 years, maybe longer than that. Do you think that trend is going to continue?

Dr. **Hansen**. I think it probably will, and a couple of reasons for that. One, obviously, many other nations are experiencing rapid rates of economic growth and development. They are industrializing, so they have their own demand for these types of people more so than ever. The other side of it is that the opportunities for American engineering students are usually so good in the private sector and the resources available to support them in graduate training are quite limited that many of them opt to go immediately into the labor market. Meanwhile, many foreign students are financed by their governments. They come in with abundant resources and as a consequence of this we have seen a steady rise in the proportion of graduate students who are foreign nationals, especially in the field of engineering. And given faculty salaries, given the cutbacks at universities, given increases in tuition rates, I think it's going to take a major effort to increase the enrollments of native American or, I should say, American students in engineering. It's too bad, but that's the way it is.

Mr. **Fuqua**. Why does that difference exist, the greater demand for foreign nationals and, more particularly, Asians?

Dr. **Hansen**. Well, I think that there is a big demand for American trained and American Ph.D.'s in engineering. The difficulty is that the faculty salaries have fallen behind, very badly, and even though institutions have made a major effort to raise the salaries of engineering faculty vis-á-vis other faculty in the humanities, it still has not been enough because you got this tremendous demand from the private sector for well-trained Ph.D.'s. So the likelihood of keeping many of them in the academic field is diminished, but those who might want to aspire to academic training are going to be deterred by the relatively low salaries that are offered.

Moreover, the starting engineer who simply completes the bachelor's degree can go out and probably earn a salary that will be higher than a brand-new assistant professor in engineering at most of the major research universities. So why endure 4 or 5 more years of starvation, hard work and so on when you can go out and receive a salary that is commensurate with what you would otherwise get after 5 years?

So the economics of it are such—and people, young people are very responsive to economic forces—they are against higher enrollments of American students.

Mr. **Fuqua**. If economic forces work, and we got into this discussion the other day, then why aren't more women and minorities going into engineering because we find that, and you may have additional information, there is a large number of women who enter the profession of law, medicine, several of the other professions; and yet if there is this economic incentive, not necessarily to be a professor but to work for private enterprise or in some other professional capacity, why isn't the economic incentive pulling those

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people in there or does all the economic theory we know break down at that point?

Dr. **Hansen**. A couple of points I think are relevant. One is that the field of engineering has been subject to enormous fluctuations, for some of the reasons I mentioned. We had a buildup in the Korean War, the space efforts and you had this sort of roller-coaster level of activity, largely the result of changes in Federal spending for research and purchasing products that engineers produce. Consequently, salaries go up, lots of people are attracted into engineering at the undergraduate level. All of a sudden the bottom drops out and there are surpluses of them. That has not been lost on young people who recognize that there is much greater volatility in this field than there would be opting for a career in medicine or law.

The second point is that if one takes a look at the enrollments of college students now compared to, say, even a decade ago and if you look at the majors chosen by women and by men, there has not been significant change in the pattern of enrollments. The proportions of women moving into or undertaking majors that might be regarded as traditional female majors—and I hate to even put it that way—is not that different than it used to be, and why this happens is something we don't know.

If more women were moving into majoring in the sciences, mathematics, in substantially larger numbers than they are now, then I would be much more optimistic about it. You might want to have Sue Berryman come in from Rand who has done a lot of work on this topic, but women seem to be responding, I think, to opportunities that seem perhaps most accessible to them, and law and medicine have made enormous efforts to bring women into their programs. Business has been very aggressive in trying to hire women. But I don't think they probably see engineering as offering the same opportunities for them, despite the fact that I am sure they are very, very good. So women don't take enough math in preparation in high school. They come into college. Lots of majors are preempted from them, and so we have a perpetuation of these old patterns.

Mr. **Fuqua**. What are the major factors then that affect the scientists and engineers?

Dr. **Hansen**. With respect to——

Mr. **Fuqua**. Students going into those fields.

Dr. **Hansen**. In some ways some of these patterns are fairly stable. As I recall, the proportions—and I think it's mentioned here in the report—the proportions of undergraduates majoring in, you might say, science-engineering related fields has probably diminished in the past decade or two. People have opted for business, professions, not the humanities, of course; and it's not clear that people are really responsive on the science and engineering margins. It takes—I think these are seen as tough majors. You got to come in with good preparation from high school, and you have a steady diet of math and tough science courses, and lot of people don't prefer to go that route.

So I think that there has perhaps been much less attention given to opportunities in these fields. It's been dominated by the yuppie success stories of people who become lawyers, physicians and business executives.

Mr. **Fuqua**. You also talk about the number of 18- to 24-year olds that will decline drastically over the next 5 to 10 years, and at the same time that very few faculty slots would become vacant.

Dr. **Hansen**. Right.

Mr. **Fuqua**. Is that an indication that the enrollment in engineering schools is likely to decline?

Dr. **Hansen**. Well, my guess is that, yes, it is, unless a significantly larger proportion of undergraduates opt for engineering. But the market for engineers has sagged a bit in the last couple years and enrollments have dropped off a bit. But as you have the number of 18-year olds going down and, as I recall the numbers, in 1962 we had something like 4.3 million people reaching age 18—I'm sorry. In 1962 we had 4.3 million people born. By 1970 that had dropped down to about 3.1, 3.2 million. It's perhaps up to 3.4, 3.5 million. You have a 25 percent decrease in the space of about 10 years in the number of people born who 18 years later will be potential college entrants. That is an enormous decline and, given the fact that colleges tend to have these student-faculty ratios they try to hold onto, and given the fact you are probably not going to have the enormous numbers of these older students entering in engeering and scientific fields, you are going to have a decline in the number of faculty and that's going to make it harder then to recover. Indeed, people like Charlotte Kuh and Roy Radner talk about the lost generations of scholars who have not been hired, who will have drifted off into other activities and there is no way to really retrieve them. You become obsolete fairly quickly, and you don't stand a chance of competing for tenure slots unless you are doing research and the like. Much of what they do outside, it's fine activity, but it's not the sort of thing that cuts a lot of ice in academic promotions. So there are real problems.

One other thing I should mention. Maybe you should talk to Gene Frankel afterward, but I think if one disaggregated some of the projections you would find that there would be more constraints in particular fields. You know, if you carry on a high-level aggregation like all engineers, the whole thing may balance out for all scientists. Once you break it down into some categories, then very likely you are going to see more evidence of shortfalls in particular fields and in extreme economic, very fine subfields in engineering; and my guess is there will be acute shortages there, just as there will be overages in some other categories.

Thinking about the SDI effort, there is going to be, of course, a significant demand for new engineers to staff that. Looking at some of the categories of engineers that are going to be required, they are quite exotic; and my guess is that there just aren't very many of them around, and there is certainly not very many of them being trained in those fields. So my guess is that there will be significant pressures as that activity builds up, for example.

Mr. **Fuqua**. Mr. Packard.

Mr. **Packard**. Let me yield to Mr. Lujan.

Mr. **Lujan**. I have just one question and it's a followup on what you're saying. In this task force, of course, we look for what policies we should set to encourage those activites that we want, and certainly education is one. But we really, I guess from your last statement, have—the only control that we have in order to increase the number of engineering students is to sponsor gigantic kinds of programs like SDI, like the space program, because it seems like the enrollments pretty well track the job opportunities.

Dr. **Hansen**. Right.

Mr. **Lujan**. And anything else that we do in between—you can give scholarships and those kinds of things; and unless the job market is there, you are not going to attract people in there.

I was going to ask how we get our domestic students more into it, in line of so many foreign students that we have; and one of the things is teachers' salaries, you say. But, again, that is just a very, very small part of it.

Dr. **Hansen**. Right.

Mr. **Lujan**. When people hear there is SDI, there are going to be big opportunities, and the universities begin to tell that to their students.

Dr. **Hansen**. It's a tough question. I am not sure you got many levers or buttons you can really press. Perhaps what is needed is some resurgence of public enthusiasm such as you had in the late 1950's and late 1960's that will mobilize everybody—I am not making any plea here—to provide more resources to support public education and training efforts. Just as an example of what is going on in Wisconsin, budget shortfalls, budget projections are way off. The State finds itself with a deficit of $400 million, and so they have got to cut and the university has been cut, of course. Student tuitions are going up by another $1,000 a year for out-of-State students. It's not going to make it any easier to attract good American students for Ph.D. programs.

In addition, money is being cut back for graduate students and project assistance and so on that helped to finance the training of graduate students; and so if this is repeated in many States, and very likely it will be, there will be a further sort of tightening down of higher education's efforts to be responsive to market conditions, and that is going to put the system in a further bind.

But what you people can do about that is not really very clear to me.

Mr. **Lujan**. Thank you, Mr. Chairman.

Mr. **Fuqua**. Mr. Packard.

Mr. **Packard**. Thank you, Mr. Chairman.

Do you see the field, Doctor, the field of engineering changing somewhat from the old traditional heavy construction type of engineering to a much more sophisticated, a much more delicate kind of engineering that may attract more women into the field? Certainly we have seen that in other fields where the attraction has come about partially due to changes in the field itself.

Dr. **Hansen**. Well, I probably have to confess ignorance. I don't know a whole lot about engineering. I have been on a couple of these panels and so on the National Academy released in their report last June—Jerry Haddad had been instrumental in developing—on educating tomorrow's engineers. Certainly the field of engineering is always undergoing change, but I am not sure, you know, the image of it has probably been altered that much such that—you should have some women testifying here probably—that the image has changed that much so that on the margin women are going to be attracted into it. On the other hand, as law begins to—you have plenty of lawyers and clearly we are producing far more than we need right now. As you have a growing surplus of physicians and the like, then people will be shopping around for other fields and maybe this will be the period when women will say, "Well, these other fields seem to be somewhat closed off to me, I will move into engineering."

Mr. PACKARD. That leads me to the next question. The driving force behind much of these changes, both in demographics and in enrollments, is often the standard supply and demand concept.

Dr. HANSEN. Right. Right.

Mr. PACKARD. If the demand for engineering is greatly increased, that generally will drive the economics of that field and the economics will often drive the enrollments.

Dr. HANSEN. Yes.

Mr. PACKARD. Do you see that process breaking down in the future or do you see some different ways of effectively addressing the shortages besides the standard supply and demand?

Dr. HANSEN. Well, no, I am not sure I do. And, in fact, this may be the salvation. For example, in the late 1980's, early 1990's, the proportion of the young people age 18 entering college will be down. There is a new book coming out by a fellow at Brookings, Binkin, who has done a lot of work on military manpower, talking really about the difficulties that will be faced recruiting enough people for the voluntary army. Meanwhile industry will want 18-year olds and then 22-year olds. Colleges will be looking for students, and I can see the recruiters, the industry representatives and college recruiters roaming the halls of high schools trying to grab these 18-year olds and induce them to come their way because there will be relatively few of them.

Now, as this progresses through the 4-year period, you will have fewer engineers coming out, et cetera. Salaries will no doubt be pushed up for all kinds of people, and the question is what is going to be the balance between the change in salaries at the high school level and then at the college level. But assuming that there will be really tight demand, I mean tight labor markets in the early 1990's for young people, whatever their stripe, this may provide the impetus for lots of women to begin responding in ways they have not yet responded in and conceivably many more of them could flow into these fields, again provided that they are sort of ready to do so, and that's going to be reflected in large part by the kinds of high school preparation they undertake.

With the efforts being made to raise high school standards and insisting on taking a core of courses and so on, it may be that higher proportions of women and men will be prepared to move into those fields and that, I think, is a good sign. So the point is that the labor market situation in the late 1980's, early 1990's may be very conducive to bringing about this change that you are suggesting.

Mr. PACKARD. Also in your testimony you alluded to the decline of faculty in the future.

Dr. HANSEN. Right.

Mr. **Packard**. And, of course, the decline of dollars available for grants and for other incentives for them to come into the field.

Dr. **Hansen**. Right.

Mr. **Packard**. Do you see where the private sector may find a desire to keep the quality of their engineers and scientists up to the levels that they need? Do you see where they may come in and fill much of that void, that the Federal dollars or public dollars are not going to be there?

Dr. **Hansen**. I certainly think that the private sector is very aware of what its interests are, and they will take action. For example, we have already—as I mentioned, several foundations and corporations have given money to universities to help finance graduate education. There is much closer collaboration growing between universities and the private sector, much more interaction among them, I think a gradual increase is going to be found in the funding provided by the private sector for universities, and I think a lot of it will go into very applied fields like business and engineering where the payoff is going to be seen to be much more obvious than, say, the support of basic research.

To the extent that happens, this is going to make it easier to have funds to retain faculty, to support student research and so on, and it's going, I think, to be of considerable help. If the supply of engineering talent were to dry up appreciably, I am certain the private sector would be alarmed and would try to do something, and perhaps they can respond effectively because they can turn it on and off more easily than I think we can often with legislative programs.

Mr. **Packard**. I think historically also we have seen where the labor market—and that certainly reflects directly upon the education market—has gone through phases in terms of attractiveness and some are very exotic at a certain period of time. Obviously law has been and medicine has been in the past.

Dr. **Hansen**. Right.

Mr. **Packard**. And we now have a surplus. We will probably see a decline in the enrollments in those areas simply because, again, the supply and demand factor.

Dr. **Hansen**. Right.

Mr. **Packard**. There are few fields that are more exotic right now and appear to be in the at least short-term future than science and even engineering, and it may be that the attraction itself will accommodate a good deal of the problems you enumerated in your testimony that are more of the negatives.

Do you see that as—do you see the science and the engineering field itself going through a transition now where it is looked upon as the future, particularly in areas like genetic engineering and in some of the more sophisticated engineering areas rather than, again, the old traditional heavy engineering?

Dr. **Hansen**. Well, I guess my one personal feeling is that there are tremendous opportunities for young people in those fields, but how widely this is seen among young people is not at all clear to me. I think that 4-year degree recipients think of getting into business and so on, and there has been a real resurgence of interests in the private sector when you contrast the situation 10 years ago when the private sector was seen as a rather evil source of salaries and jobs, do good in the public sector, and I think a lot of talented young people turned away from the private sector back 10, 15 years ago. Now there is a great move back toward the private sector because Government is not expanding. But I am not sure that the opportunities in science and engineering are seen as all that alluring to young people.

Mr. **PACKARD**. One last question, if I may, Mr. Chairman.

The decline in the faculty and the decline in the numbers and the attraction to the private sector which pulls them away—good Ph.D. engineers away from the educational field and professorships—do you see that that can have an adverse effect upon the quality of the education of this field and, therefore, feeds the same concerns that you have expressed?

Dr. **HANSEN**. If it were this afternoon, I would have some very new, interesting data on faculty salaries which has just been released, but I don't have them in my hands yet anyway, showing salary changes by discipline; and clearly in the last 10 years the faculty salaries have increased differentially by field. The biggest increases, as we know, have been in engineering, business, computer sciences and the like. That trend is continuing, and so this is going to—this is a response really to what is going on in the private sector.

Now, if you take a look at what faculty people leave academic institutions, typically it's the best people that leave because somebody has identified the talents that they have and puts together a package that will lure them away. I think it would be very hard to document changes in the quality of, let's say, engineering faculty; but my guess is it probably, certainly has not gone up and probably diminished because good people are always in demand; and so as you pull away your best people, if that indeed is what is happening, it results in some people who are still around who are less talented, less able.

The same thing happens at the graduate level. The best engineering students command enormous salaries, and they say:

"Well, why should I hang around here for graduate training when, if it's going to take 4 or 5 years, the salaries are not all that attractive if I am in for an academic job, if I am in for a research job, but I will try it as a bachelor's-degree holder and see what happens. Maybe I will come back later on."

So, again, the best people are lured away. The least talented are the last in the queue to be hired. They are all hired, of course, but you get this differential allocation by quality of performance and achievement.

So one further element in all of this, is if American students go out and find their fortunes in jobs immediately and do not continue in graduate school, and the number of new Ph.D.'s is therefore constrained, you will have large proportions of foreign students acting as teaching assistants in the undergraduate programs and larger proportions of them will eventually become faculty members. I think that has some implications for American higher education. I think that these people will be typically less well acquainted with American institutions and so on. It will change the character of undergraduate education, perhaps graduate education as well. It's probably less important at the graduate level where it's more specialized, but at the undergraduate level I think it's—one should be concerned that the proportion of foreign nationals who are teaching does not rise and become too large. I think we will lose something in the process.

Mr. **Packard**. It seems that like the testimony is for them to have a better cooperative effort, maybe a marriage between the private sector and the education or the academic sector in the future in order to somewhat blend the quality of the private sector with perhaps a lack or a loss of quality in the academic sector.

Thank you, Mr. Chairman. That's all I have.

Mr. **Fuqua**. Mr. Lundine.

Mr. **Lundine**. I'm sorry I was late, but I did have a chance to quickly read your testimony.

Do we have any idea of how many scientists and engineers we will need 10 or 20 years in the future? I understand it's about three percent of the population right now. Given that it's a technological society, is there any way of projecting a likely demand?

Dr. **Hansen**. Yes. The Bureau of Labor Statistics does that quite regularly, and just in November in the *Monthly Labor Review* published revised projections for 1995 of the requirements for engineers of various types and categories, scientists and 200 occupations, the whole gamut. So the information is out there. Now, whether or not—how seriously you take it is another question. I did an evaluation of some of the projections for engineers in a National Academy report that came out a year or so ago, and there are, you know, wide disparities in the projected figures and the actual figures that then materialized. This is for 1980 and 1985, large discrepancies. So there are these estimates but, you know, how much faith you put in them is something you have to decide for yourself.

Mr. **Lundine**. What we can do by studying demographics is look back at what our supply, at least our domestic supply, is likely to be and it strikes me how infrequently we have done that in the past in all sorts of ways. We have built schools when it was utterly predictable we wouldn't need them and like that.

Dr. **Hansen**. Right.

Mr. **Lundine**. If we are to look at that today and assume that there will be some shift based on the market conditions you have just been talking about, but assume some of the pessimistic outlook you do in your testimony, that there are just not going to be hordes of women or minorities getting into these fields, is it then clear that there is going to be a serious shortfall of people in these fields?

Dr. **Hansen**. Well, I guess it depends on your view of the world. If you say markets work quite effectively, then you say somehow we will make it and, indeed, we have made it before. You think back to the buildup in the Korean War, the space efforts, et cetera, I don't think we had any massive public programs to augment the supplies of people in these fields, but you make it somehow, although perhaps with some lag.

Now, that says, "Well, don't worry about all of this; it will all take care of itself." In one sense it will, although perhaps not as quickly as one might hope; but the greatest force for change is some kind of tension and to the extent you have a disparity between what you think you need and what seems to be out there, this is going—people are going to have to begin responding, institutions, employers and the like, got to change salary schedules or find other ways to induce people to change their behavior.

So this will set off a whole chain of action and reaction. So in that sense, you know, one would say, "Forget about this, don't worry about it." On the other hand, I am sure you will receive lots of complaints and there will be a lot of concern expressed in the coming decade about these slow reactions here and that will make it tough for staffing various Federal programs and maybe private sector opportunities.

Mr. **Lundine**. Well, I think though that there are often dramatic events that focus public attention.

Dr. **Hansen**. Right.

Mr. **Lundine**. Change attitudes also. I believe in the dynamic of market forces, but can vividly remember in the late 1950's and early 1960's the impact that Sputnik had.

Dr. **Hansen**. Right.

Mr. **Lundine**. And then the impact that the space program largely articulated by President Kennedy had, and it's true that probably scholarships and financial things had an impact, and certainly young people's perceptions of where they can find a job has an impact, but it seems to me that back then there was a whole lot of discussion such as we are having, which is all well and good, but there were also dramatic events that kind of positively focussed the public attention. And I can't foresee into the future, but at this point I don't see that in our society today.

Dr. **Hansen**. Well, I think that we need people that generate those kind of events and maybe you are one to help to do that. I agree. I think that the—there are these dramatic events that really have tremendous impact, and we need some comparable Sputnik flying around the space up there or some other technological breakthrough. Maybe the Soviets, we should pray they do this so it will alert us to action that will convey to young people that science and engineering are very, very important fields, that we have got to do a lot, we have got to have more people come in and there are opportunities there and so on. Then a lot of these things could take care of themselves.

It's not just market forces. It's often these external events that are of critical importance. How you sort of generate a change in public attitudes and all is unclear. On the other hand, look what has happened in public education in the last couple of years. It was way down on the agenda. It's now up there near the top. This is not a result of spending vast amounts of money. It was a result of some reports, PR, et cetera and public education at the precollege level is now in the front ranks of public concern. Why? How? Maybe there is a lesson there for science and engineering.

Mr. **Lundine**. In your judgment—do you teach undergraduate classes?

Dr. **Hansen**. And graduate students.

Mr. **Lundine**. I am particularly interested in the undergraduate classes. Many of us have been exposed—if you have community colleges in your district, I am sure you were exposed last week to the community college people coming in; and I was frankly shocked—I had three, happen to have three in my Congressional District—by the agreement that they had over the basic competence of high school graduates or the lack of competence of high school graduates. How fast do you think we can turn that around from the time a fairly dynamic society says we want excellence in education—how fast do you think that we could expect to see a turnaround in just basic literacy and computing skills of people coming out of high school?

Dr. HANSEN. That is a tough one. I don't think it's going to be easy and, you see, I think undergraduates are on the average less well prepared than they were 20 years ago.

Mr. LUNDINE. How about 10 years ago?

Dr. HANSEN. Probably not much difference 10 years ago. I think there was a real breaking point in the late 1960's, and then you were still seeing the Sputnik generation in the colleges and things began to go downhill fairly rapidly, I think in high schools and colleges alike, in the turmoil of the late 1960's. Recouping is going to be, I think, far more difficult now because of the change in family structure, among other things, many more single-parent families, increasing proportion of minorities, television, the whole list of things that I think have just detracted from academic achievement and performance. So I think it's going to be very, very hard to reverse that—very hard.

Mr. LUNDINE. In just a reading of your testimony I find it very depressing. Maybe that is too strong a word.

Dr. HANSEN. I didn't mean to do that to you.

Mr. LUNDINE. You say—well, other than saying the OTA report was well done, basically I don't see that you are suggesting solutions. It seemed to me that you are saying——

Dr. HANSEN. No.

Mr. LUNDINE [continuing]. That some of the solutions that are suggested by people are probably not likely to pay the dividends we think they are, and we should be realistic; and your last comment, I would guess, is realistic. But what do we do other than tell me to be a dynamic leader and cause tremendous public attention to be focused? What do you think are some of the solutions? For example, to be more specific, let's take the issue of the college graduate in science or engineering making the decision that you were talking about in response to Mr. Packard's question as to whether he or she goes out and accepts a fairly attractive job but not a get-rich proposition or stays and takes graduate courses. Other than salary, are there other things we could be thinking about doing? Make a better life, more exciting, more comfortable?

Dr. HANSEN. I was just talking yesterday morning with a student who is getting a master's degree in industrial relations, and he is just about ready to accept a job with a major American corporation. And he has done some work with me on labor markets for sort of the highly trained people, and he said one of the fascinating points that came out in his discussion with these people is that by and large they hire engineers and after 6 or 7 years they get rid of them, and he was amazed by this. And I was trying to probe to find out what it is, whether or not—whether they become technologically obsolete that quickly or what it is. He said he really hasn't been

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able to ascertain why but if he took a job there he hoped he might be able to find out.

One difficulty is engineers become obsolete fairly quickly. If you look at earnings profiles, they start at high salaries, but the rate of increase is not at all that great. There is a kind of tradeoff. You get a high starting salary. You may get locked into the current technology which is practiced by that firm, and your opportunities for maintaining your human capital, your intellectual capital, for acquiring new knowledge of new technologies that are developing becomes limited, and I think maybe perhaps that view is seen by lots of young people. This looks good to begin with, but where are you going to be in 5 or 10 years?

Mr. LUNDINE. That gives rise to just one further question, Mr. Chairman.

The one encouraging thing I see—or one of the encouraging things I see in the trends going on right now is that we are gradually coming to the understanding that learning is a lifelong process and you don't have to be 22-years old to go to graduate school or whatever.

Dr. HANSEN. Exactly.

Mr. LUNDINE. What I wonder is whether we could develop a program of fellowships or something that would be attractive to the very people you lost 5 or 6 years ago; you lost some of the best and brightest engineers and scientists who decided to go out for one reason or another, went into private industry, maybe they either lose their jobs or get disillusioned with what they are doing and would love to come back. Now, that is not easy because they are probably at a time when they are forming families and all those kinds of pressures are coming in on them; but I think there is a real opportunity if we could broaden our horizons out from just worrying about the kids who are juniors and seniors in college. Is there anything that you see going on where either Government or industry plus Government, plus universities themselves, are pursuing anything like that?

Dr. HANSEN. One thing that I have been impressed with is the push by professional schools, especially business and law and other sort of public policy-type programs, to increasingly insist people go out for a couple years to find out what life is about. They come back much more focused in their study for, let's say, a master's degree. I think that is all to the good. Too often students have been in school too many years and they are sick of it and they go through the motions but nothing much happens. Perhaps what is needed would be some kind of program that would encourage people who have been out a few years to come back and get some kind of master's degree that would sort of bring their skills up to the frontier again, to the extent that can be done, and maybe this is the way to do it.

A lot of people have gotten degrees and they realize, well, they are not utilizing the skills or now they realize what they could do and perhaps some program of that kind would help retrieve these people who have a lot of talent but who sort of get locked out because of what they majored in, what they decided to do 8- or 10-years ago. That might be one avenue that I think has worked successfully in helping a lot of people in public policy programs and industrial relations programs, business and so on, to come back and have a second chance to get on track. You know, there are some people who said education is wasted on the young, and there may be a lot of truth to that. Coming back in your late twenties you might be far more focused and what you do far more valuable than what you are doing from 18 to 22.

Mr. **Lundine**. Thank you, Mr. Chairman.

Mr. **Fuqua**. Thank you, Mr. Lundine.

I wish we had more time. We have another hearing that I have got to go start on energy, but I did have a question, and the staff will present it to you, about changing demographics of high school graduates and the impact on out-of-State, percentage of students who go to out-of-State schools and either increasing or changing of emphasis on engineering schools or science and engineering schools that is related to a chart on page 39 of the report.

Dr. **Hansen**. I would be glad to answer that.

Mr. **Fuqua**. I would appreciate if you have any figures you could answer that for the record.

Dr. **Hansen**. Fine.

Mr. **Fuqua**. We may have some others, Dr. Hansen. Thank you very much. I enjoyed it.

[Whereupon, at 9:35 a.m., the task force recessed to reconvene on March 5, 1986, at 8:30 a.m.]

[Questions and answers for the record follow:]

June 2, 1986
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Responses to Questions for the Record Committee on Science and Technology U.S. House of Representatives

Question 1. In the OTA study it is noted that in the period between now and year 2000, the "Sun Belt" states will experience a very large growth in the number of high school graduates (i.e. Florida: 20%, Texas: 19%, New Mexico: 11%, California: 18%). In the period the "Frost Belt" states will experience significant drops in the same number of high school graduates (i.e. Michigan: 30%, New York: 28%, Pennsylvania: 28%). What data do we have about the fraction of a state's high school graduates who do go to college, do so in the same state. How many go to college out of state? What, in your view, are the implications for Federal policy with respect to the support of scientific research at our universities?

The U.S. Department of Education compiles state-by-state information each year on the number of high school graduates per 1,000 population and also the number of college students per 1,000 population. Unfortunately, there is no way of knowing how these figures are affected by the enrollment of students who are not state residents or who are not long-time state residents. In the case of high school graduates the vast majority of them are residents. But for college students this is less likely. The reason is that considerable numbers of students attend colleges in other states. Decause the flows of high school graduates to colleges in other states varies so much, no precise relationship between high school and college enrollments can be established for individual states. The former U.S. Office of Education used to do a survey every five years to ascertain the mobility of college and university students. As I recall, questionnaires were sent to colleges asking them for a breakdown of their undergraduate enrollments by state of residence. This information proved to be highly informative but the surveys were discontinued about the mid 1970s. It seems quite likely that this information could be collected, though with some paperwork burden on academic institutions. There is wide variation, of course, with the University of Wisconsin-Madison typically having about 25 percent of its undergraduates from out of state whereas the University of Kansas probably has less than one percent of its undergraduates from out of state.

The implications of student mobility for Federal policy with respect to the support of scientific research in our universities are nil. I see absolutely no connection between student mobility and levels of support for scientific research.

Questions 2. In the OTA study it is concluded that there is a high degree of correlation between the GNP and the number of engineers employed in the U.S. This conclusion is based on the observation that both GNP and the Number of engineers doubled between 1960-1982. Is this an adequate basis for establishing such a correlation? Are there other data and studies which confirm this correlation or lead to other conclusions? In your view, how confident can we be that the close relationship between the GNP and the number of engineers employed will remain true in the decades to come?

This correlation is analogous to those nonsense correlations one reads about in elementary statistics books. I would guess that similar correlations exist for any number of other occupations. How such correlations are to be interpretated is anyone's guess. I would not attach any importance whatsoever to this correlation except for the fact that it arouses some curiosity. The more basic question you may want to consider is what role engineering and engineers play in the process of economic growth. I don't know of any studies that really address this question in a careful way. Answering such a question would be difficult; indeed, it might prove to be impossible to answer with any degree of certainty.

Question 3. What are the major factors that affect the supply of scientists and engineers in a given field and what additional information is needed to better understand the future supply of personnel trained in science and engineering?

It is unfortunate but true that we know relatively little about the determinants of the supply of scientists and engineers in a given field. Typically, we think of the flow of say PhD scientists and engineers being determined largely by the numbers of people entering PhD training which in turn are a function of the numbers of bachelor degree recipients a year earlier. Whether these people are attracted by the money, the prestige, or something else is not clear. At the same time some people completing undergraduate degrees in adjacent fields may switch their field of graduate study and thereby augment the number of trainees in a particular field. At a later date, PhD graduates in a field may opt to enter some other often related field, either because of personal interest or better opportunities, including higher pay. Still another complication arises because some people completing degrees in other fields may decide to enter this particular field. And after entry into the labor force there is often considerable occupational mobility between fields, known as field-switching. For all of these reasons there is no close connection between the kind of training people receive and the fields in which they work. Nor do we know exactly what draws people into these fields. In some of our work on the labor market for PhD economists, we experienced great difficulty in developing a useful predictive model that tracks the changing flows of new PhDs into the economics profession (see American Economic Review, March 1980). Efforts to extend the model into the early 1980s have not been very successful, largely because of our limited capacity to capture the complexity of these kinds of labor markets and the factors that are most critical in affecting individual choices.

Questions 4. The projections of future undergraduate enrollments is based on the expectation that the percentage of all those in the 18-21 year old group in any future years, who will go to college, will be 27 percent. Since the number of faculty positions closedly ties to the number of undergraduates to be taught, this projection appears to be of high importance. Do you see any reasons why the 27 percent figure will, in future decades, be significantly higher or lower?

Even if the enrollment rate has always been 27 percent, it is not clear that this was known with any certainty beforehand and thereby made planning for the hiring of faculty members any easier. The trouble is that faculty members are experts in particular fields whereas the student body finds its interests in academic programs changing in response to labor market conditions, national concerns, new technological developments, and the like. Thus, the distribution of the enrolled student body changes and makes it difficult to anticipate exactly how many of each particular kind of faculty member to whom long-term job commitments are made will be needed in some future year. In addition, we know that over the past decade there has been a considerable increase in the enrollment of persons 25 years of age and over. This came as a complete surprise. The composition of this older group of students differs, with a large proportion of them being women who are more likely than not to enroll in fields similar to those chosen by younger women. These fields do not usually include science and engineering. What the future will bring is difficult to foresee. I would not be willing to bet any substantial sum of money that even if the 27 percent rate has held in the past it will continue into the future. Whether the rate will be higher or lower is difficult to say. For example, the college-age population will be declining into the early 1990s, and this may intensify the competition between postsecondary education institutions and employers for the age 18-24 year old group. Depending upon the strength of these two groups, the enrollment percentage could go up or down. Employers may need workers so desperately that they will be willing to pay substantial wage premiums and thereby lead larger propositions of high school graduates to take jobs and cause fewer of them to enroll in college. On the other hand, colleges and universities may argue persuasively that the long-term opportunities will be far better for those who do have a college degree, with the result that young people will resist the attractive pay offered by employers and enroll in college at higher rates than now.

Questions 5. About 3 percent of the U.S. work force today are scientists and engineers. Is there reason to believe that the technological society of tomorrow will require a higher percentage of personnel trained in science and engineering?

Trying to peer into the future, particularly when it comes to speculating about the personnel trained in particular fields, is a terribly difficult task. I don't think we know the answer or even know how to obtain an answer. Our record with occupational projections has been dismal over the years, even for projections made over decade-long periods. And yet it is probably safe to say that the proportion of the labor force involved in scientific and engineering activities will increase. By how much it will increase--that is where the difficulty comes. Our problem arises because as economic and technological conditions change it becomes possible to substitute other types of personnel to perform some of the tasks of scientists and engineers. We know relatively little about how these substitutions work, and it is extremely difficult to predict them with any accuracy.

Questions 6. In the OTA report it is stated that a surge in demand for university faculty is likely to occur in the period 2000-2010. Because of the time it takes to train new PhD's, and because demand for PhD's will be low in the early and mid-1990's, fewer students are likely to enter and graduate from the PhD pipeline. OTA therefore suggests that it may be necessary to institute "counter-cyclical support programs in the early 1990's." What should the nature of such programs be, in your view?

I do not know what OTA had in mind, and I perhaps they themselves were not clear and hence could not spell out what they meant. Various options are available. Even in the currently depressed academic labor market, various foundations, notably the Mellon foundation. are providing fellowships to graduate students in the humanities so as to assure a steady stream of new blood into the humanities fields. The federal government could so something similar to this, much as was done in the late 1950s and early 1960s through National Science Foundation fellowship grants and National Defense Education Act Fellowships. As another possibility a National Research Council report several years ago suggested that government funding be made available to open up new faculty research positions so that highly talented research scientists could find academic positions. In short, there are a variety of things that can be done. All will cost money. How successful they will be is not clear. Nor is it obvious that once these programs are organized they can be easily shut off after the immediate problem lessens in severity. In fact, the situation faced in the early years of the 21st century will be unique. Any policies that will be implemented must deal not with cyclical problems but rather with the much more important structural changes facing the American economy. For my own part I am rather skeptical about the efficacy of such programs in dealing with a temporary situation of the kind outlined.

Questions 7. In the OTA report it is concluded that there is no strong relationship between graduate enrollment in science and engineering and changes of the graduate school population. What does affect the graduate college enrollment?

It is quite apparent that the relationship people once thought operated with respect to cohort size and graduate enrollments fell apart in the 1970s. The number of new PhDs was projected by the late Allan Cartter to continue increasing steadily throughout the 1970s and 1980s. In fact, PhD production hit its peak in the early 1970s and its level has remained about constant since then. It seems quite clear that the declining opportunities for teaching and research positions caused many young people to shift into other training streams, such as law and medicine, or to take other kinds of jobs. Contributing to this shift is the substantial decline in the real level of faculty salaries that occurred during the 1970s. Real salaries for college and university faculty members declined by over 20 percent from 1970 to 1980 but since then have recovered somewhat so that they are now only 15 percent lower in real terms (i.e., adjusted for inflation) than they were in 1970. Exactly what weight should be assigned to the constancy in the level of PhD production by real salary declines remains to be ascertained.